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Division Report

HUMAN WASTE STUDIES IN AN OCCUPIED CIVIL DEFENSE SHELTER

AMC PRON NR. W4-5-C0619-05-A1-EF
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Errata

Page	Paragraph	Line	Should Read
1	1	10	an adjunct to not a part of
13	-	1	As a(2), p. 3 not above
15	last	5	facultative not faculative
15	last	10	was not were
19	2	6	insert: "per vault," after tap water.
58	2	7	Bacteria not bacteia
59	1	1	revealed not revelaed.
63	1	3	additional not additonal
64	1	6	comma (,) after siphoning

PREFACE

The investigation covered in this report was conducted under the authority of AMC PRON NR. W4-5-C0619-05-A1-EF, AMCMS Code No. 5900.21.26525, OCD Project Order No. OCD-OS-63-235, OCD Sub-Task No. 1331A, approved 4 June 1965.

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The views contained herein represent only the views of the preparing agency and have not been approved by the Department of the Army.

TABLE OF CONTENTS

Section	Title	Page
	PREFACE	ii
	SUMMARY	iv-v
I.	INTRODUCTION	
	1. Subject	1
	2. Background	1
II.	INVESTIGATION	
	3. Description of Test	3
	4. Experimental Methods	15
	5. Results	19
III.	DISCUSSION	
	6. Examination of Test Results	52
	7. Evaluation of the Sanitary Vault and Chemical Agent	61
IV.	CONCLUSIONS	
	8. Conclusions	66
	REFERENCES	67
	APPENDIX	68

SUMMARY

This report covers human waste studies conducted in an occupied Civil Defense fallout shelter facility. Both the sanitary vault waste system and preferred chemical odor control agent were evaluated under these shelter conditions.

This report concludes that:

a. It is practically impossible to prevent male shelterees from standing while urinating.

b. The use of a vapor barrier chemical, oleic acid, does not appear to reduce emanation of waste gases appreciably.

c. "Apparent" fecal odors are a result of inherent psychological factors, propagated by both the sight and subsequent nearness of the human waste before the elimination process begins.

d. Odors of the type experienced in this test - chemically stale urine - can be reduced substantially by closure of the commode seat after each usage.

e. So long as the predetermined concentration of chemical agent, namely, 12,000 ppm $CuSO_4.5H_2O/NaHSO_4$, is maintained and the sterilant mixture allowed to mix with the waste in a homogeneous manner, bacterial growth is minimal.

f. The per capita human waste deposition rate is 1.2 lbs/person/day or 0.13 gal/person/day.

g. The present design of the sanitary vaults used in this study does not lend itself to shelter usage and further modifications are indicated.

h. The Civil Defense dual-purpose container is the more practicable and economical method for storage of human waste in the confined environment of a fallout shelter.

HUMAN WASTE STUDIES IN AN OCCUPIED CIVIL DEFENSE SHELTER

I. INTRODUCTION

1. Subject. The objective of this study consists of the evaluation under fallout shelter conditions of (1) the sanitary vault/diaphragm pump waste system for collection of human waste and (2) the effectiveness of a preferred sanitizing agent for treatment of these wastes. Contract DA-44-007-AMC-537(T) was awarded to Truesdail Laboratories, Inc., Los Angeles, California, to perform laboratory investigations and recommend the most effective odor control chemical agent for treatment of human waste, and design, fabricate, and furnish four sanitary vaults. The final report covering their endeavors is included and made a part of this report. The human waste system evaluation study was conducted by the Sanitary Sciences Division, USAERDL, Fort Belvoir, Virginia, in cooperation with representatives of Civil Defense Research, Psychological Laboratories, University of Georgia, Athens, Georgia.

2. Background. One important technical problem encountered in the present shelter program is that of a need for efficient, low-cost sanitation systems for the disposal of human wastes. The methods for such treatment must (1) prevent the spread of enteric diseases and (2) eliminate the possibility of morale-lowering factors associated with the inherent odors and other disagreeable aspects of human excreta.

Previous investigations concerned with the evaluation of low-cost sanitation systems have resulted in the utilization of the sanitary vault concept as an approach to this problem. The basic features of the present configuration of this system are (1) a single vault or receptacle which initially would contain a supply of disinfecting and odor control chemicals and be designed to receive all wastes, (2) two seats which permit direct deposition of wastes into the vault, (3) a vent, from the chamber, directed to the outside of the shelter, (4) a non-corrosive screen, to prevent large materials from entering the suction side of the pump, and (5) a hand-operated scraper, to clean the screen of any clinging residue. A simple, manually-operated diaphragm pump and hose is used in conjunction with the sanitary vault to empty the unit in the event of prolonged, excessive usage or between periods of short duration. The effluent can then be disposed of by truck, if available, or by deposition into a septic tank, a dry well, or an existing sewerage line.

Present studies have provided data relative to the effective dosages of the most efficient and economical odor control chemical combination tested, namely, cupric sulfate pentahydrate and sodium bisulfate. At concentrations of 4,000 and 8,000 ppm, respectively, cupric sulfate together with sodium bisulfate provide good disinfection and odor control of the wastes deposited in the Civil Defense dual-purpose containers. The chemical mixture is to be provided in both one-half and one pound packages.

II. INVESTIGATION

3. Description of Test. These Laboratories participated in a simulated fallout shelter test conducted at the University of Georgia, Athens, Georgia, for the period 19 through 26 June 1965. The shelter test involved the use of 305 individuals (138 males and 167 females) with ages varying from 2 to 67 years. The facility used consisted of an old, three-story warehouse - the Costa Building, located near downtown Athens (See Figure 1). Sections of two floors were transformed into shelter areas.

Three sanitary vaults (See Figure 2 through 4) were installed in the shelter: two on the first floor and one on the second (See Figures 5 through 9). These vaults provided two female and one male commode areas. A second male commode area, on the second floor, was equipped with the metal, dual-purpose drum. A simple, hand-operated diaphragm pump and hose were used in conjuction with the sanitary vault for emptying purposes. Metal, dual-purpose drums were provided as containers for the waste when the diaphragm pump was employed.

The chemical agent was furnished in one-half and one pound pouches and was used on the basis of one pound of agent per 10 gallons of human waste.

Wall signs were posted as follows:

a. Male Commode Areas:

(1) PLEASE BE SEATED WHILE URINATING.

(2) FOR HUMAN WASTE ONLY: NO TRASH, GLASS, ETC.

Figure 1. The Costa Building - Fallout Shelter Facility.

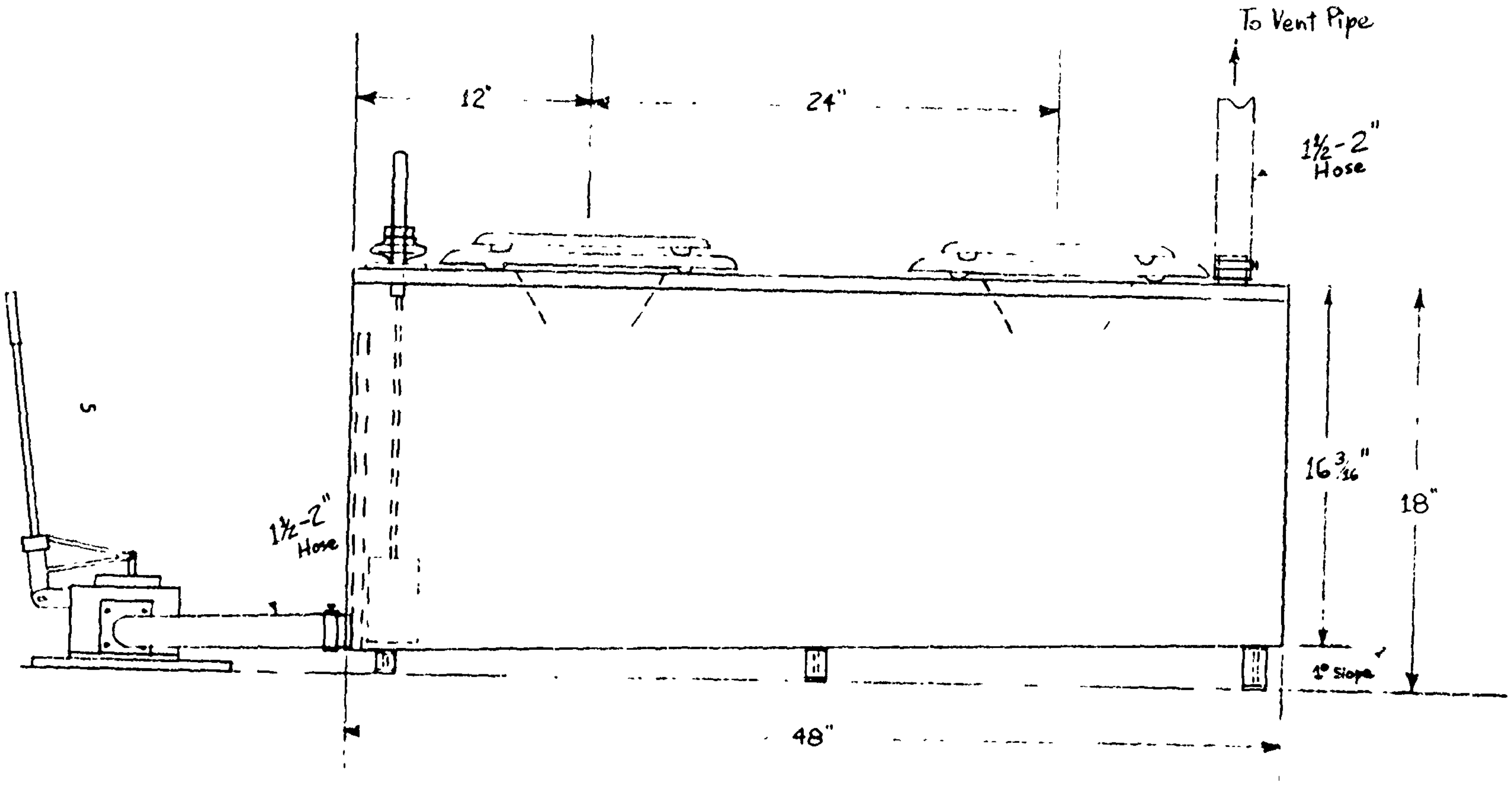

Figure 2. Side View of Sanitary Vault/Diaphragm Pump Waste Collection System, 100-gallon.

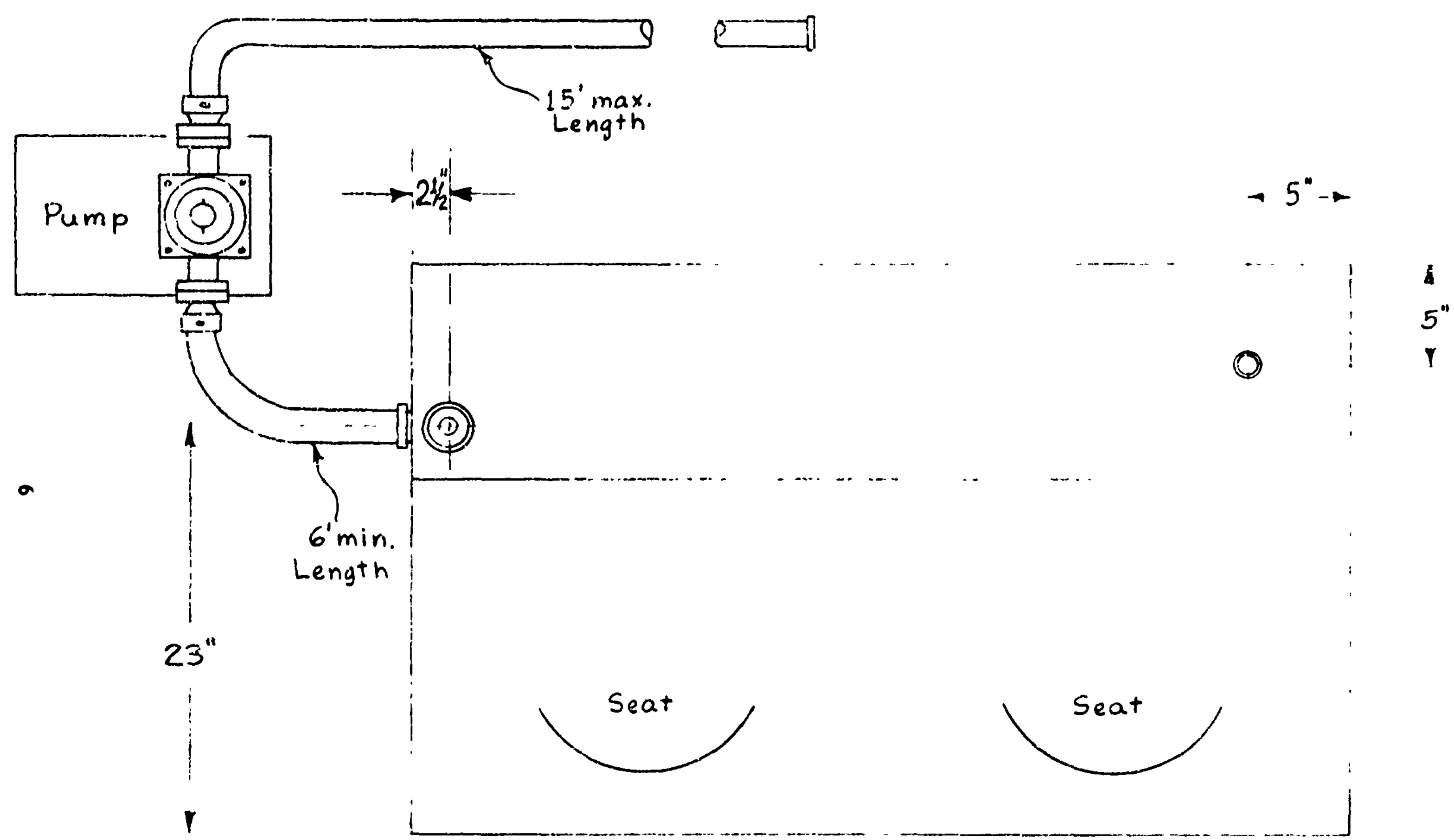

Figure 3. Top-View of Vault and Diaphragm Pump Assembly.

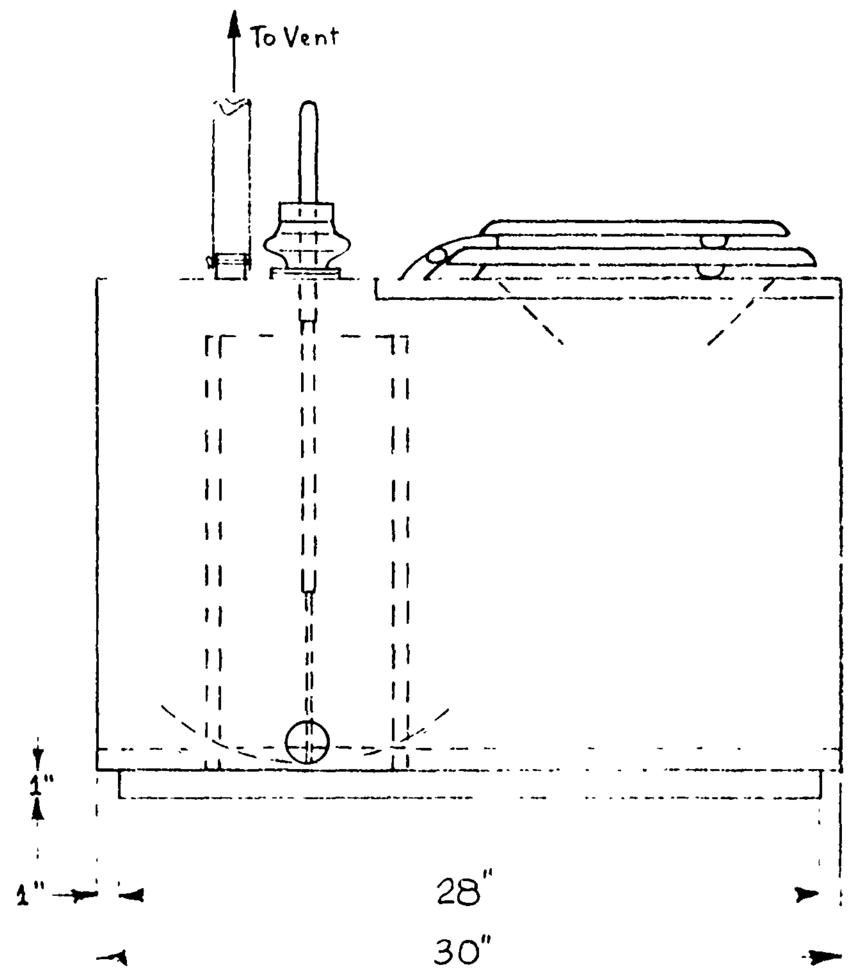

Figure 4. End-View, Depicting Discharge End of Tank.

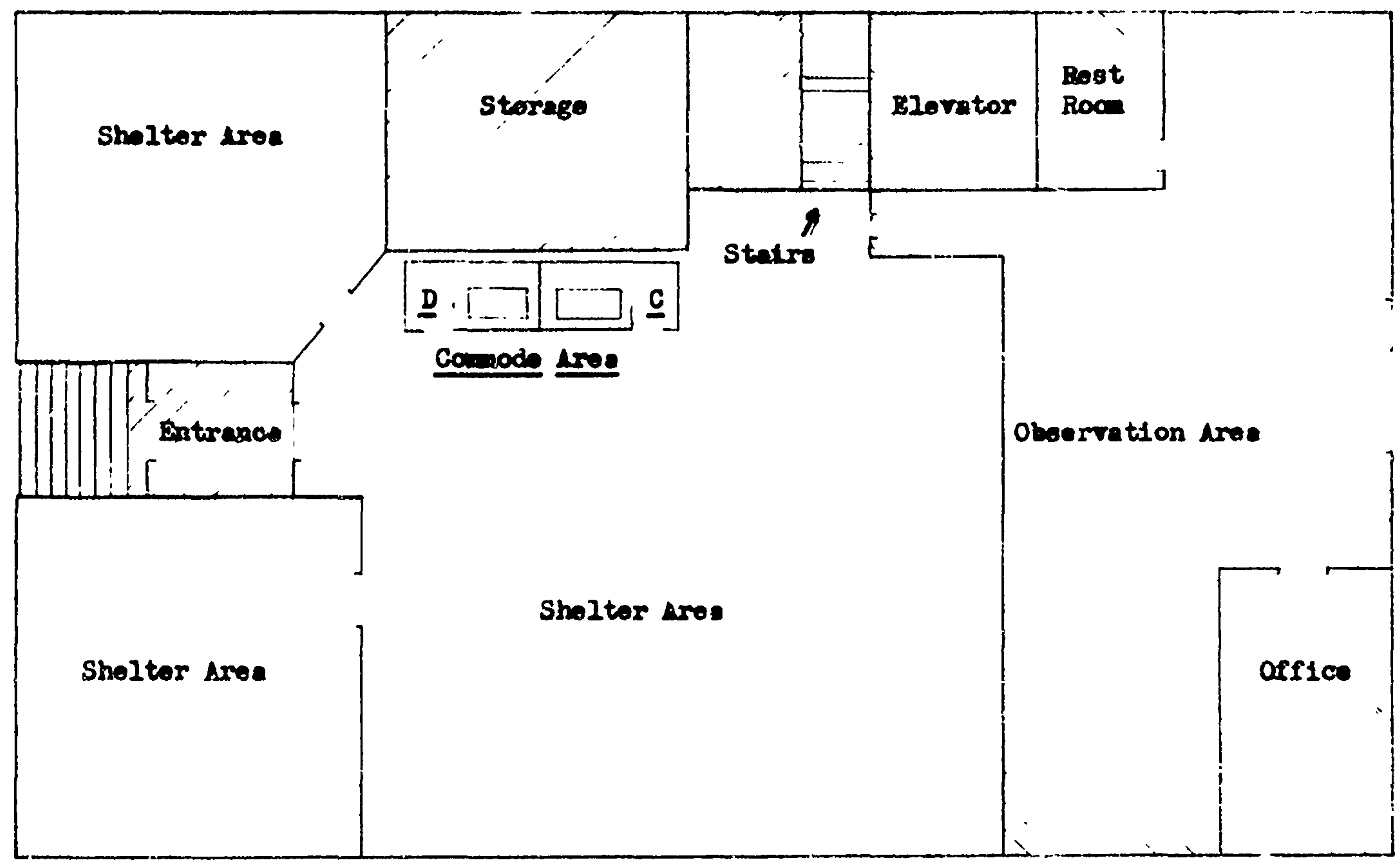

Figure 5. Fallout Shelter Facility, First Floor.

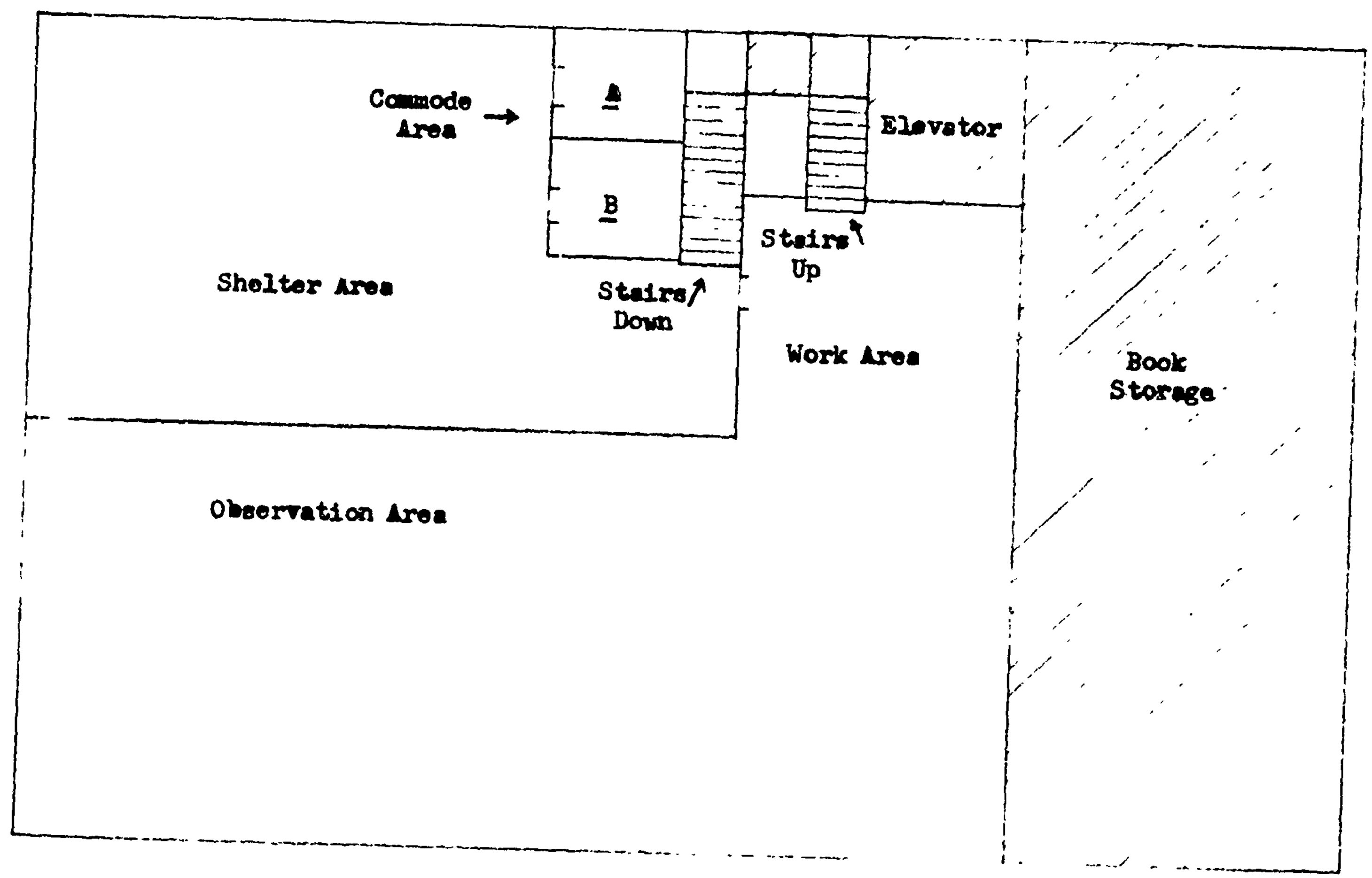

Figure 6. Fallout Shelter Facility, Second Floor.

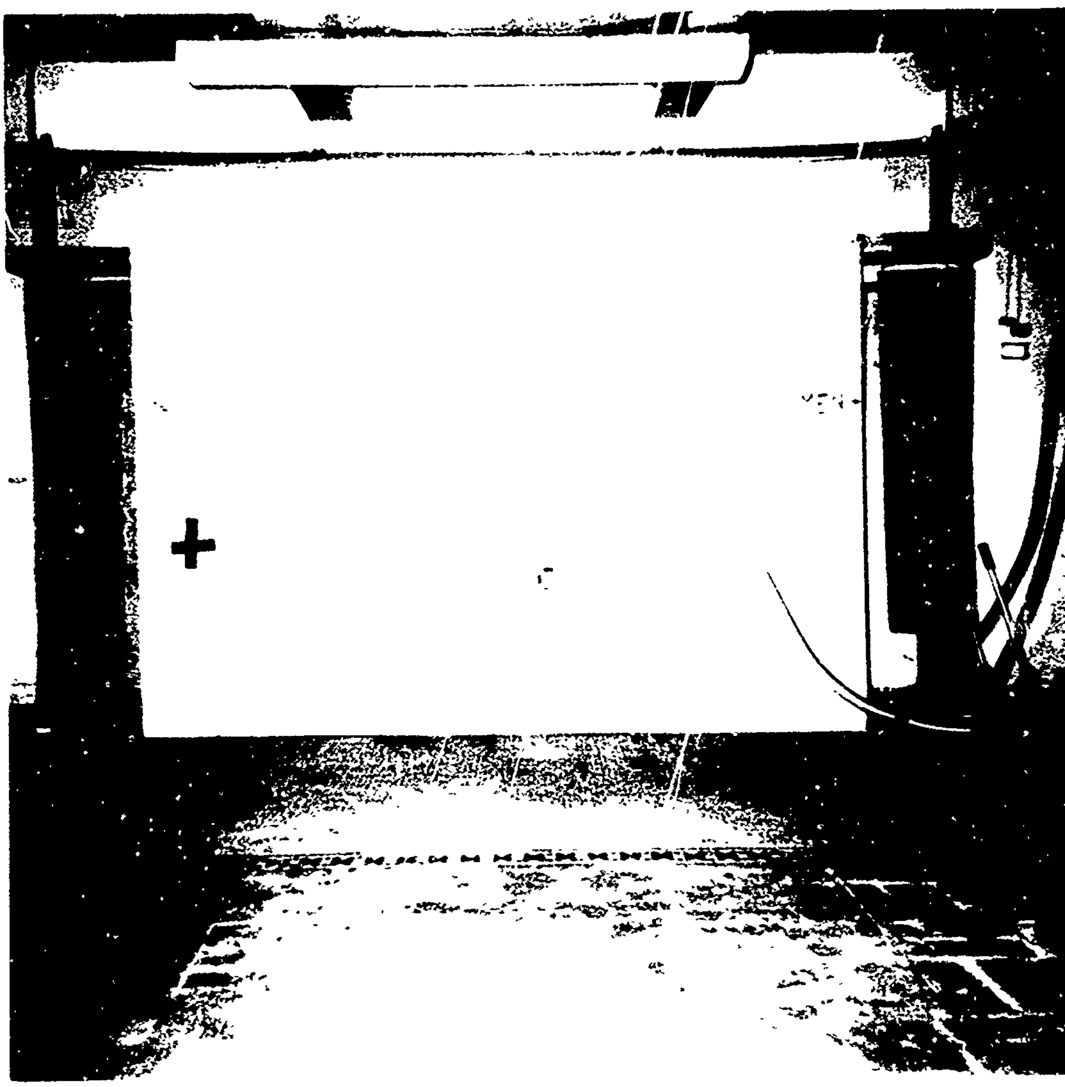

Figure 7. Male and Female Commode Areas D & C, First Floor.

Figure 8. Female Commode Area B, Second Floor.

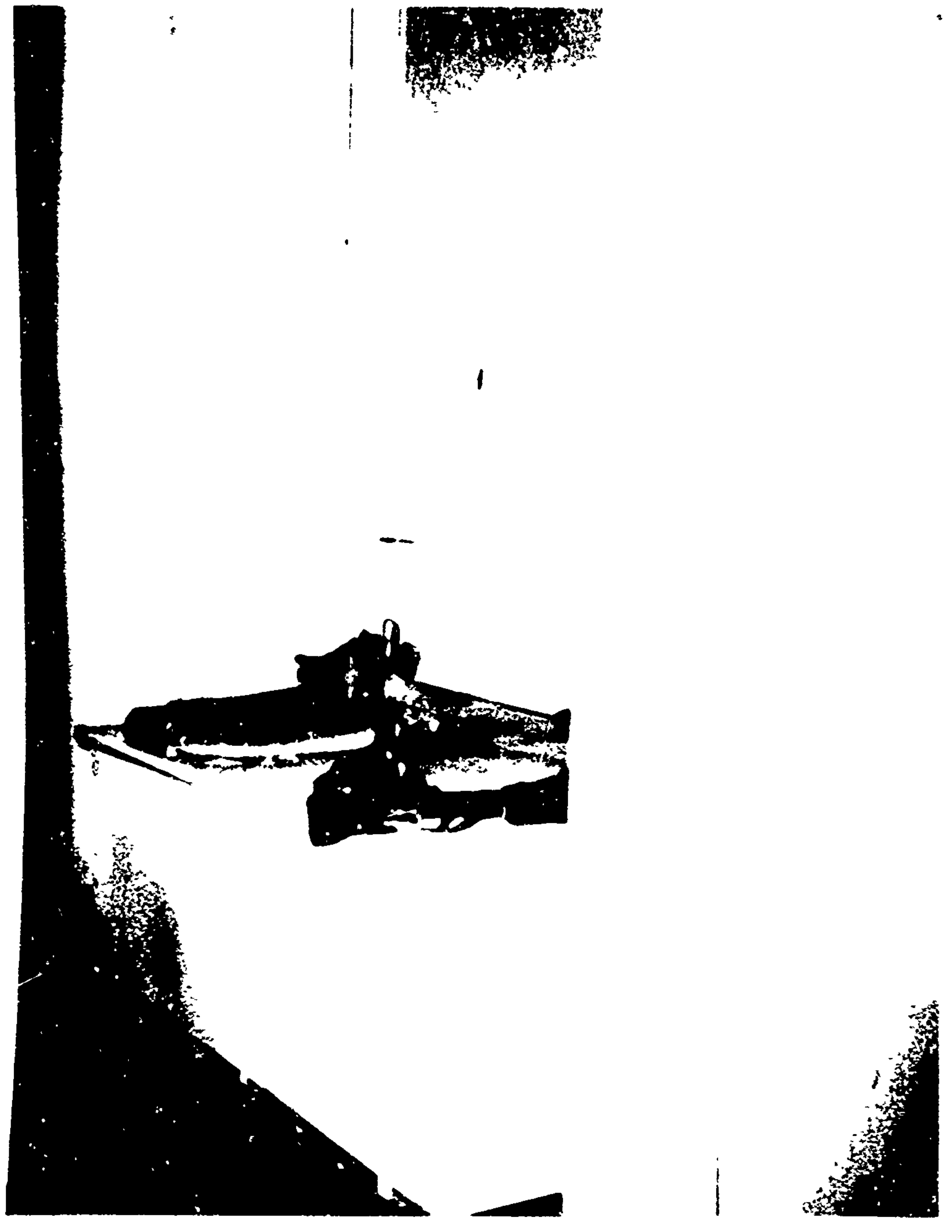

Figure 9. Sanitary Vault Installed in Area B.

b. Female Commode Areas: As a(2) above.

Data sheets on clipboards, with pencils attached, were supplied in each commode area for the purpose of recording: (1) bowel movements, (2) urinations, (3) subjective odor responses, and (4) time of usage. A complete daily log was maintained of all pertinent data and occurrences, such as weights of chemical agents added at the specific time and waste level; height of waste in commodes, and time when waste was pumped manually into metal drums. (This log may be found in the Appendix of this report.) Weights of human waste were measured outside the shelter using a medical-type scale.

Samples for bacteriological analyses were collected once per day per commode. These samples were submitted to the laboratory in appropriate containers. The number of the specimen, time, and place of collection, were entered on Form DD 6-86 and this form was attached to the specimen container with a rubber band. Special care was exercised so as not to soil the outside of the sample container.

The specimens were processed in the laboratory (See Figure 10) within one hour after delivery and no longer than two hours after collection. The following tests and bacteriological analyses were made:

a. Organoleptic odor and pH determinations.

b. Gas formation using the Smith Tube technique.

c. Viable bacteria count (colony count).

d. Coliform group bacteria.

(1) Presumptive test.

(2) Confirmed test.

Figure 10. Laboratory Facility Used for Bacteriological Analyses of Water and Waste Samples.

(3) Completed test.

(4) Differentiation of members of coli-aerogenes group by IMVIC reaction.

e. Demonstration of Clostridia.

f. Tests for the presence of Enterococci.

(1) Presumptive test.

(2) Confirmed test.

g. Gram stain of isolated bacteria, where necessary.

4. Experimental Methods. Volumes of waste, in gallons, were determined using the following relationships:

a. Vol. = height x 0.795 (for metal drums)

b. Vol. = height x 5.72 (for vaults)

The height of the waste in the respective commodes was measured with a common yardstick at specific times.

For the purposes of this study, the standard procedures and media used for the bacteriological analyses are described in Standard Methods for the Examination of Water and Wastewater, 11th ed., 1960, and Diagnostic Bacteriology, 5th ed., Schaub *et al*, 1958. The presence of aerobic and faculative anaerobic, nonsporeforming, rod-shaped bacteria, commonly known as the coliform group, was demonstrated by the multiple-tube fermentation technique (presumptive, confirmed, and completed tests), and the Most Probable Number of bacteria present in 100 ml (MPN) was computed with the aid of tables. In addition to these tests, the total number of viable bacteria per 100 ml of sample were estimated by the standard plate count technique at 35 $\pm$ 2°C incubation.

The samples also were tested for Enterococci, another species of bacteria which is useful as an indicator for pollution. A wide range of dilutions was chosen for the determination of the MPN of both coliform bacteria, Enterococci, and colony counts. Samples were removed from the commodes using sterile, polyethylene basters and/or stainless steel ladles (See Figures 11 and 12). The sample tube was submerged from 2-3 inches below the liquid level in the commode and its contents discharged into collection cups. In the laboratory, samples for analysis were removed from the supernatant liquid with a sterile pipette.

The following table indicates the media used for the specific bacteriological tests performed:

Table I. Media Used for Bacteriological Tests

Test	Media
Viable Count	Tryptone Glucose Extract Agar
Coliforms:	
Presumptive	Lactose Broth
Confirmed	Brilliant Green Lactose Bile Broth and Eosin Methylene Blue Agar
Completed	Eosin Methylene Blue Agar and Lactose Broth
Clostridia	Litmus Milk/Thioglycollate
Enterococci:	
Presumptive	Azide Dextrose Broth
Confirmed	Ethyl Violet Azide Broth
Smith Tube	Glucose Broth

Figure 11. Technician Taking Waste Sample from Sanitary Vault with Baster.

Figure 12. Technician Removing Waste Sample from Dual-Purpose Drum with Ladle.

In addition to the previous tests, Smith Tubes with glucose broth were used to indicate gas formation by organisms capable of gas production from glucose under aerobic conditions. Organoleptic odor determinations were made by pipetting 75 ml waste samples into 125 ml Erlenmeyer flasks and incubating at 35$\pm$2°C for three days; daily checks for development of odor were routine. Colony characteristics, differential media, gram stains, morphological characteristics and IMVIC reaction were employed for identification of the organisms.

5. Results. The four commode areas were activated at 1330 hrs, Saturday, 19 June. Since two SK4 commode drums were in operation between 1200-1330 hrs, both were removed from the shelter. The three sanitary vaults each contained one pound of the cupric sulfate pentahydrate/sodium bisulfate chemical agent dissolved in 2 quarts of water (See Figure 13). Ten gallons of tap water were used to permit a minimum liquid depth of one inch per vault. The other commode area, located on the second floor, was designated for male use. In this area, A, were employed metal, dual-purpose containers. One-half pound of chemical agent dissolved in 2 quarts of water was added to the drum.

Since there was a two-year old boy present, a diaper container was installed in female area D and instructions were written on the wall above. Samples for bacteriological analysis were taken at approximately 1000 hrs daily after the first day, on which no sample was removed.

The results of the first day's study were a preview of the problems that were inevitably to occur. Due to the lack of Commode

Figure 13. Technician Filling a Sanitary Vault with Chemical Agent, Area C.

Monitors, this is, shelterees designated by the Shelter Manager to be responsible for and administer the individual commode areas, normal sanitation was neglected. The male vault and dual-drum both showed signs of urine spillage. It became evident that the male shelterees were not sitting while urinating, as requested by the signs. In the female commode areas, B and D, toilet tissue was beginning to pile up directly under the seats. Towards the end of the first day, the odor of mildly stale urine appeared.

Odors of stale urine became increasingly more pronounced during the second day of the test, 20 June. Urine was found on top of the vault and on the floor in C. Perhaps the most important cause of the stale urine odor was the seat covers which were left open in areas C and D. The odor in area B was not as perceptable, since the seats ormally were kept closed. Each time a sample was taken or the height of the waste measured, the heaped tissue, etc., was pushed down and away from the drop-zone with a long-handled, wooden spoon.

On the third day, 21 June, a few women bagan to complain about the odors. By that same afternoon, complaints were steady. The odor which prevailed was not fecal in nature, but that of stale urine, caused by the reaction of the chemical agent with the waste. Sanitary napkins were being deposited both in the vaults and the trash cans. One 10-gm package of SK4 phenolic agent was sprinkled into the trash can containing the used napkins in area B. Two 10-gm packages of the phenolic agent were added to the trash container in area D. Since odors from this container were very bad, it was removed and a new one installed.

On the fourth day, the female sanitary vault in D was scheduled to be pumped out. The shelterees were advised by the Shelter Manager to move to one side on the first floor, away from the commode area. The plastic gate valve on the vault was opened. The cord, which fastened the discharge hose to the wall (See Figure 14), was loosened and the hose was placed in an empty, polyethylene-lined, dual-purpose drum. Three males were utilized for the pumping operation: a first, to direct the discharge hose into the metal receptacles; a second, to accomplish the actual pumping; and a third, to manipulate the scraper located on the vault proper. Pumping proceeded smoothly for a short period (See Figure 15); then the scraper failed and fell into the vault. Toilet tissue, sanitary napkins, debris, etc., had to be removed manually from the screen attached to the vault. Pumping became increasingly difficult and eventually had to be terminated due to blockage of the suction hose with foreign material. Only 5-1/4" or 30 gallons of waste were pumped from the vault. The three metal drums containing the pumped waste were removed from the shelter. A sample for bacteriological analysis was taken. Due to the presence of debris in the suction hose in the area surrounding the screen, the plastic gate valve was impossible to seat properly. Some slight leakage around this area was noticed at that time. The commode area and sanitary vault were washed down with an Ozene solution. Ozene was supplied as a commercially-available sample (emulsifiable ortho-dichlorobenzene), which was offered as a water-soluble and/or fungicidal agent to be used as a cleaning and disinfecting solution for commode tops, seats, and

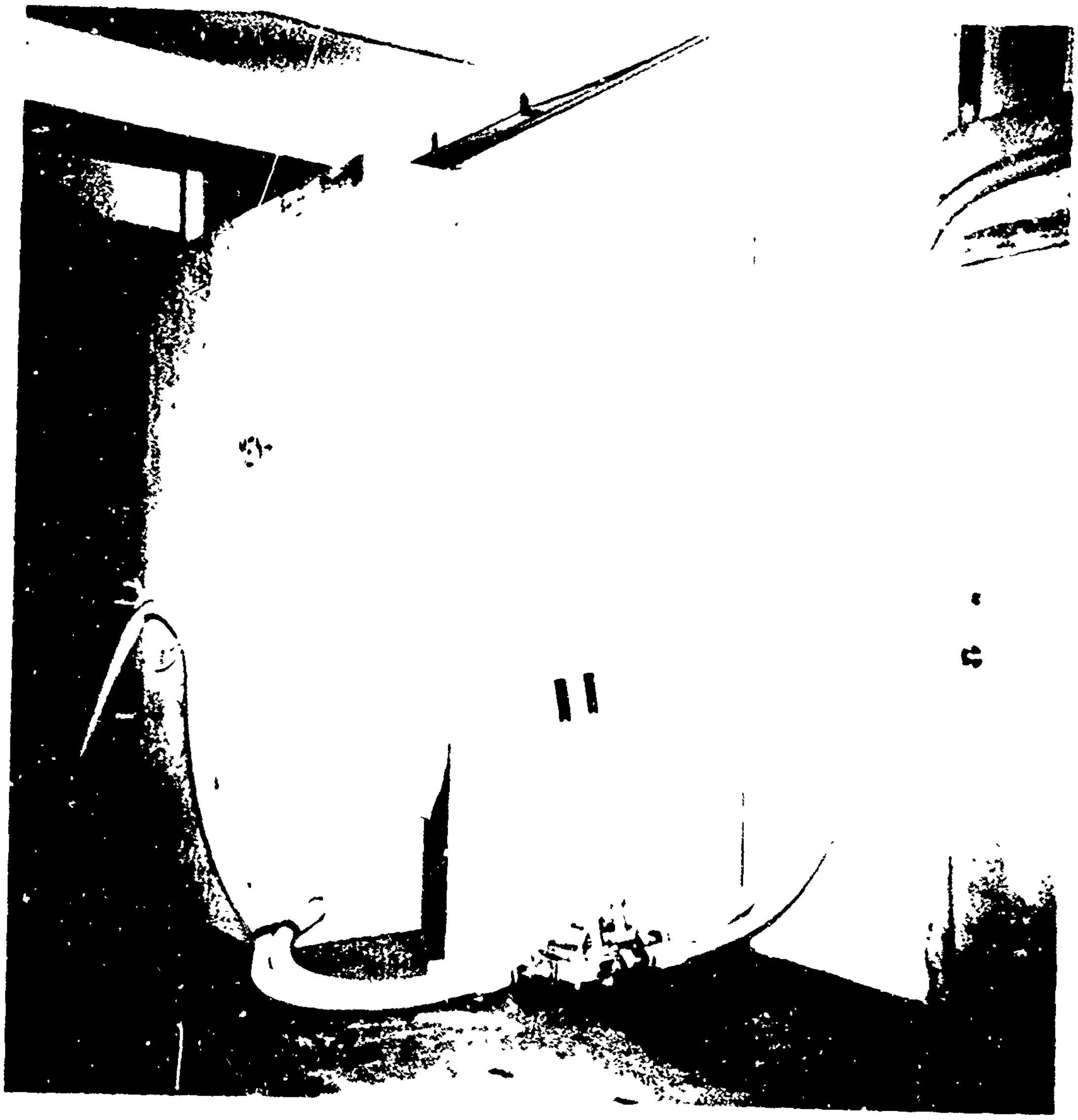

Figure 14. Location of Diaphragm Pumps and Hose on First Floor.

Figure 15. Technician Pumping Waste from Vault D with Diaphragm Pump.

floors, when required. Into the remaining waste (4-3/4" or 25 gal) were deposited the following: 2 lbs of chemical agent dissolved in 2 quarts of water and 1 gallon of oleic acid. Oleic acid was recommended, as a result of a previous contract, for possible use as a vapor barrier. Oleic acid, being an oily, essentially-inert liquid, floats on water or liquid waste and prevents waste gases from escaping to the atmosphere.

Because the sanitary vaults in both female areas B and D were being filled rapidly with excessive toilet tissue, an attempt was made to improve conditions before they became intolerable. The following written instructions were given to the Shelter Manager for use as a guide to improved shelter sanitation:

After area D is pumped out and a new charge of chemical agents added and the floor and the commode sterilized:

a. Appoint a shift of Commode Monitors.
b. No child under 12 years allowed in commode facility without a parent or adult. (Commode Monitor must check.)
c. If any urine is spilled on seat or commode, the individual making the mess will be responsible for cleaning it up. If it is not cleaned up, the Commode Monitor will then have the responsibility for maintaining good sanitary conditions. (Commode Monitor must make sure that toilet tissue used for washing, cleaning up urine, etc., is placed in the trash can, NOT in the commode.)
d. Toilet tissue dispensing will be administered by the Commode Monitor and returned to her after each usage. The excessive use of toilet tissue MUST terminate.

In other words, the responsibility for toilet cleanliness is now on the female shelteree's shoulders (where it should be), not on the experimentor's.

These suggestions were implemented by the Shelter Manager and distributed to both male and female Commode Monitors.

By the next day, 23 June, the sanitation conditions had degenerated to about the same level as was experienced previously. Many shelterees either did not care or simply did not know anything about basic sanitation practices.

On the previous evening, an emergency developed. Leakage from vault D was sufficient to warrant the concern of the shelterees whose bedding was located immediately adjacent to the commode housing structure (See Figures 16 and 17). One female shelteree (the Commode Monitor at D area) had her quilt and pillowcase saturated with waste leakage. The problem was investigated and appeared to be isolated in the vicinity of the plastic gate valve on the vault. The hex bolts were tightened with a 7/16" wrench and sealing compound was packed around the "O" ring and valve assembly. Paper towels saturated with Ozene solution were placed uner the valve assembly after the floor, both inside and outside the commode area, was cleaned thoroughly with Ozene solution.

At 1100 hrs, 23 June, male sanitary vault in C area was prepared for the pumping operation. The vault was emptied until the diaphragm would not function due to jamming of the check valve on the suction side of the pump. The discharge hose had to be drained by gravity so as not to present any difficulties after the hose was attached in its proper position on the wall. The total waste removed was only 2-7/8" or 16.5 gallons. Although the volume of toilet tissue

Figure 16. Bedding of Shelterees Near Commode Area and Location of Medical Station, First Floor.

Figure 17. Commode Area on First Floor with Shelterees.

was considerably less than in the female vault, sufficient quantity passed through the screen and blockage occurred. Later, it was determined that the scraper had also failed and had fallen into the vault. It was now decided not to attempt to pump out vaults C and D, but to allow the waste to accumulate to the 9" level (50 gallons); then the vaults would be taped shut and dual-purpose drums would be utilized during the remainder of the test.

On the following day, 24 June, a routine daily inspection of the four commode areas was made. In area A, the odor was rated bad to fair due, mainly, to the drum cover not being in place. An entire roll of toilet tissue was found in the drum, thus absorbing all the liquid and causing the serious odor. In area B, the odor was definitely fecal in nature. Toilet tissue and bloody sanitary napkins were piled under the seats to a level slightly higher than the bottom of the splash plates on the vault. This vault could not possibly have been pumped out due to the extremely high tissue/liquid ratio. Therefore, it was decided, as in the previous cases, to tape shut the vault when the waste reached the 9" level. Metal drums would then be utilized. Area C was typical of the male commode facilities in that urine was found everywhere: on the seats, vault top, floor, and walls. The female vault in D contained a tremendous volume of toilet tissue and sanitary napkins. The odor was very bad and was definitely fecal. The reason for such a disagreeable odor was obvious (See Figure 18), since human stools lay on the tissue above the liquid level and, therefore, the chemical agent was rendered ineffective.

Figure 18. Human Stool Atop Pile of Toilet Tissue, Vault D.

At 2145 hrs, 24 June, the dual-purpose drum in A was secured and removed from the shelter. Another metal drum was introduced containing a new chemical preparation: 1 pt Ozene and 1 gal water. The disinfecting capability of Ozene was to be evaluated.

Both B and D female vaults were taped shut and metal drums containing the $CuSO_4/NaHSO_4$ agent added. A total of four drums were employed.

During the course of the study certain unsanitary practices were noticeable while water was being distributed to the shelterees. Samples of the water were taken at arbitrary intervals. Routine water tests for coliform organisms were employed as recommended in "Standard Methods for the Examination of Water and Waste Water." A total of seven samples was removed for bacteriological analysis. Table II contains the results of the bacteriological tests performed on the water samples. In some instances, the specific organism responsible for the contamination was identified. Tables III - VIII delineate all bacteriological analyses performed together with subjective odor determinations.

The shelterees, 243 total, were allowed to leave the shelter facility at 0900 hrs, Saturday, 26 June. This number represented 80 percent of the individuals initially in the shelter at the commencement of the test. Table IX depicts the number of shelterees present during the course of the test.

Immediately after all the shelterees had departed from the shelter, an inspection of the four commode areas was made. All vaults

Table II. Drinking Water Bacteriological Analyses

DATE	LOCATION	I_2	pH	DISTRIBUTION	VIABLE COUNT per 100 ml	COMPLETED	COLIFORMS* MPN	LOWER	UPPER	ORGANISMS ISOLATED
21 Jun	1st floor, left	-	-	-	0	0	-	-	-	None
21 Jun	2nd floor	-	-	-	-	0	-	-	-	None
24 Jun	1st floor, center	-	-	unsanitary dispensing	10^3	+	>8	8	∞	*E. coli*; *Aerobacter aerogenes*
24 Jun	2nd floor	-	-	unsanitary dispensing	4×10^3	0	-	-	-	*Staphylococcus epidermidis*
25 Jun	1st floor, left	+	7.4	unsanitary dispensing	0	0	-	-	-	None
25 Jun	1st floor, center	0	7.3	contaminated water added	890	+	>88	88	∞	*E. coli*
25 Jun	2nd floor	+	7.1	sanitary dispensing	0	0	-	-	-	None

* Expressed as organisms per 100 ml.

Table III.

Smith Tube Gas Formation and Organoleptic Odor Determination, A & B Areas

DATE	SMITH TUBE mm gas	COLOR OF SAMPLE	ODOR 24 hrs	ODOR 48 hrs	ODOR 72 hrs
Male Dual-Purpose Containers, A.					
20 Jun	-	dark green	xxx	-	-
21	-	dark green	xxx	xxx	xxx
22	-	dark green	xx	xx	xx
23	28	dark green	xxx	xxx	xxx
24	-	-	-	-	-
25*	32	light brown	Ozene	Ozene	Ozene
26*	10	dark amber	NH_3	NH_3	NH_3
Female Sanitary Vault, B.					
20 Jun	-	dark amber	xx	-	-
21	-	dark amber	xx	xx	xx
22	-	dark green	xx	xx	xx
23	0	dark green	xx	xx	xx
24	-	dark green	x	xx	xx
25	0	dark green	x	xx	xx
26	+	dark amber	xx	xxx	xxx
26 Drum-1	0	dark amber	xx	xx	xx
26 Drum-2	0	dark green	xx	xx	xx

Code: x - slight odor of stale urine.
xx - odor of stale urine.
xxx - strong odor of stale urine.
* - Ozene used instead of original chemical agent.

Table IV.

Smith Tube Gas Formation and Organoleptic
Odor Detemrination, C & D Areas

DATE	SMITH TUBE mm gas	COLOR OF SAMPLE	ODOR 24 hrs	48 hrs	72 hrs
Male Sanitary Vault, C.					
20 Jun	-	amber	xx	-	-
21	-	light green	xx	xx	xx
22	-	green	xx	xx	x
23	0	green	xx	xx	xx
23 after pumping	10	dark green	xx	xx	xx
24	0	dark green	x	x	x
25	0	dark green	x	x	x
26	0	dark green	xxx	xxx	xxx
Female Sanitary Vault, D.					
20 Jun	-	green	-	xx	-
21	-	green	xx	xx	xx
22	-	green	xx	xx	x
22 after pumping	22	dark amber	xx	xx	xx
23	0	green	xx	x	x
24	-	dark green	xx	xx	xx
25	0	dark amber	xx	xx	xx
26	10	amber	xx	xx	xx
26 Drum-1	0	-	xx	xx	xx
26 Drum-2	0	-	xx	xx	xx

Code: x - slight odor of stale urine.
xx - odor of stale urine.
xxx - strong odor of stale urine.

Table V

Coliform Density and Viable Bacteria Count, A & B Areas

DATE	pH	COLIFORMS*				COLONY COUNT*
		COMPLETED TEST	MPN	LOWER	UPPER	
Male Dual-Purpose Containers, A.						
20 Jun	4.3	0	0	-	-	5×10^3
21 Jun	4.4	0	0	-	-	8×10^3
22 Jun	3.6	0	0	-	-	0
23 Jun	5.5	+	$>8 \times 10^8$	8×10^8	-	3×10^9
24 Jun	-	-	-	-	-	-
25 Jun**	6.3	+	510	50	1920	9×10^3
26 Jun**	6.5	+	-	8×10^4	6×10^6	4×10^7
Female Sanitary Vault, B						
20 Jun	2.5	0	0	-	-	0
21 Jun	2.4	0	0	-	-	0
22 Jun	4.5	+	-	8×10^6	6×10^8	13×10^6
23 Jun	3.9	0	0	-	-	0
24 Jun	4.8	0	0	-	-	0
25 Jun	1.3	0	0	-	-	0
26 Jun	5.6	+	510	50	1920	6×10^6
26 " Drum-1	2.1	0	0	-	-	0
26 " Drum-2	1.6	0	0	-	-	0

* Expressed as organisms per 100 ml.
** Ozene used instead of original chemical agent.

Table VI

Coliform Density and Viable Bacteria Count, C & D Areas

DATE	pH	COLIFORMS*				COLONY COUNT*
		COMPLETED TEST	MPN	LOWER	UPPER	
Male Sanitary Vault, C.						
20 Jun	2.5	0	0	-	-	0
21 Jun	3.3	0	0	-	-	0
22 Jun	3.5	0	0	-	-	0
23 Jun	3.9	0	0	-	-	0
23 " after pumping	4.0	0	0	-	-	10^3
24 Jun	3.8	0	0	-	-	0
25 Jun	3.9	0	0	-	-	6×10^3#
26 Jun	4.1	0	0	-	-	0
Female Sanitary Vault, D.						
20 Jun	4.7	+	2×10^6	10^5	10^7	64×10^4 (est.)
21 Jun	4.0	0	0	-	-	8×10^3
22 Jun	5.1	+	$>8 \times 10^8$	8×10^8	-	2×10^9
22 " after pumping	2.8	0	0	-	-	0
23 Jun	3.7	0	0	-	-	0
24 Jun	5.9	+	$>8 \times 10^8$	8×10^8	-	3×10^9
25 Jun	2.4	0	0	-	-	0
26 Jun	6.2	+	16×10^4	33×10^3	52×10^4	10^6
26 " Drum-1	2.3	0	0	-	-	0
26 " Drum-2	3.7	0	0	-	-	0

* Expressed as organisms per 100 ml.
# Probable contaminant; no growth in thioglycollate.

Table VII

Enterococcus Density, A & B Areas

DATE	pH	COMPLETED TEST	ENTEROCOCCI* MPN	LOWER	UPPER
Male Dual-Purpose Containers, A.					
20 Jun	4.3	0	0	-	-
21 Jun	4.4	0	0	-	-
22 Jun	3.6	0	0	-	-
23 Jun	5.5	+	>8 x 10^6	8 x 10^6	-
24 Jun	-	-	-	-	-
25 Jun**	6.3	+	510	50	1920
26 Jun**	6.5	+	510	50	1920
Female Sanitary Vault, B.					
20 Jun	2.5	0	0	-	-
21 Jun	2.4	0	0	-	-
22 Jun	4.5	+	1600	330	5290
23 Jun	3.9	0	0	-	-
24 Jun	4.8	0	0	-	-
25 Jun	1.3	0	0	-	-
26 Jun	5.6	0	0	-	-
26 " Drum-1	2.1	0	0	-	-
26 " Drum-2	1.6	0	0	-	-

* Expressed as organisms per 100 ml.
** Ozene used instead of original chemical agent.

Table VIII

Enterococcus Density, C & D Areas

DATE	pH	ENTEROCOCCI*			
		COMPLETED TEST	MPN	LOWER	UPPER
Male Sanitary Vault, C.					
20 Jun	2.5	0	0	-	-
21 Jun	3.3	0	0	-	-
22 Jun	3.5	0	0	-	-
23 Jun	3.9	0	0	-	-
23 " after pumping	4.0	0	0	-	-
24 Jun	3.8	0	0	-	-
25 Jun	3.9	0	0	-	-
26 Jun	4.1	0	0	-	-
Female Sanitary Vault, D.					
20 Jun	4.7	+	920	160	2940
21 Jun	4.0	0	-	-	-
22 Jun	5.1	+	$>8 \times 10^8$	8×10^8	∞
22 " after pumping	2.8	0	0	-	-
23 Jun	3.7	0	0	-	-
24 Jun	5.9	+	5×10^8	5×10^7	19×10^8
25 Jun	2.4	0	0	-	-
26 Jun	6.2	0	0	-	-
26 " Drum-1	2.3	0	0	-	-
26 " Drum-2	3.7	0	0	-	-

* Expressed as organisms per 100 ml.

Table IX

Weighted Average of Individuals (by sex) Occupying Shelter

TOTAL ELAPSED TIME, Hrs	MALES	FEMALES	TOTAL PERSONS PRESENT
0	138	167	305
24.5	138*	167*	305*
48.5	124	152	276
72.5	123	147	270
96.5	119	136	257
120.5	112	133	245
144.5	112	133	245
163.5	112	131	243
	——	——	——
WEIGHTED AVERAGE	120	143	263

*N.B. - Five defections on 19 Jun included in second day.

were then untaped and opened. Figure 19 shows the dual-purpose container used to hold male waste in area A. (Note the trash and untidy appearance of this area.) Figure 20 depicts the severe problem of toilet tissue accumulation in the female vault in area B. Figure 21 represents a typical view of the male sanitary vault in area C. Urine is covering most of the vault top. A roll of toilet tissue is saturated with urine, rendering it useless. The prevailing odor was that of urine. This area was a constant trouble-spot, from a sanitation point-of-view. Figure 22 presents a top view of the female vault in area D. Toilet tissue and sanitary napkins are piled above the splash plates causing strong fecal odors to emanate.

Before the vault tops in C and D areas were removed, manual pumping with the diaphragm pump was attempted. In both cases, pumping was accomplished until the depth of the remaining waste reached the height of the vault discharge hole; then pumping ceased. It appeared that the blockage had loosened. The tops of the two vaults were removed (See Figure 23) and the thick, bulk material was removed manually with an enameled scoop and placed in polyethylene-lined metal drums prior to weighing (See Figure 24). Removal of waste from the vaults was complete (See Figure 25). The scrapers were found laying on the bottom of the vaults. Both were sheared off at the point of connection with the handle.

Tables X through XIII contain data which indicate the total net volume (total net volume equals total collected or gross volume less the water added as make-up or used for dissolving chemical agents)

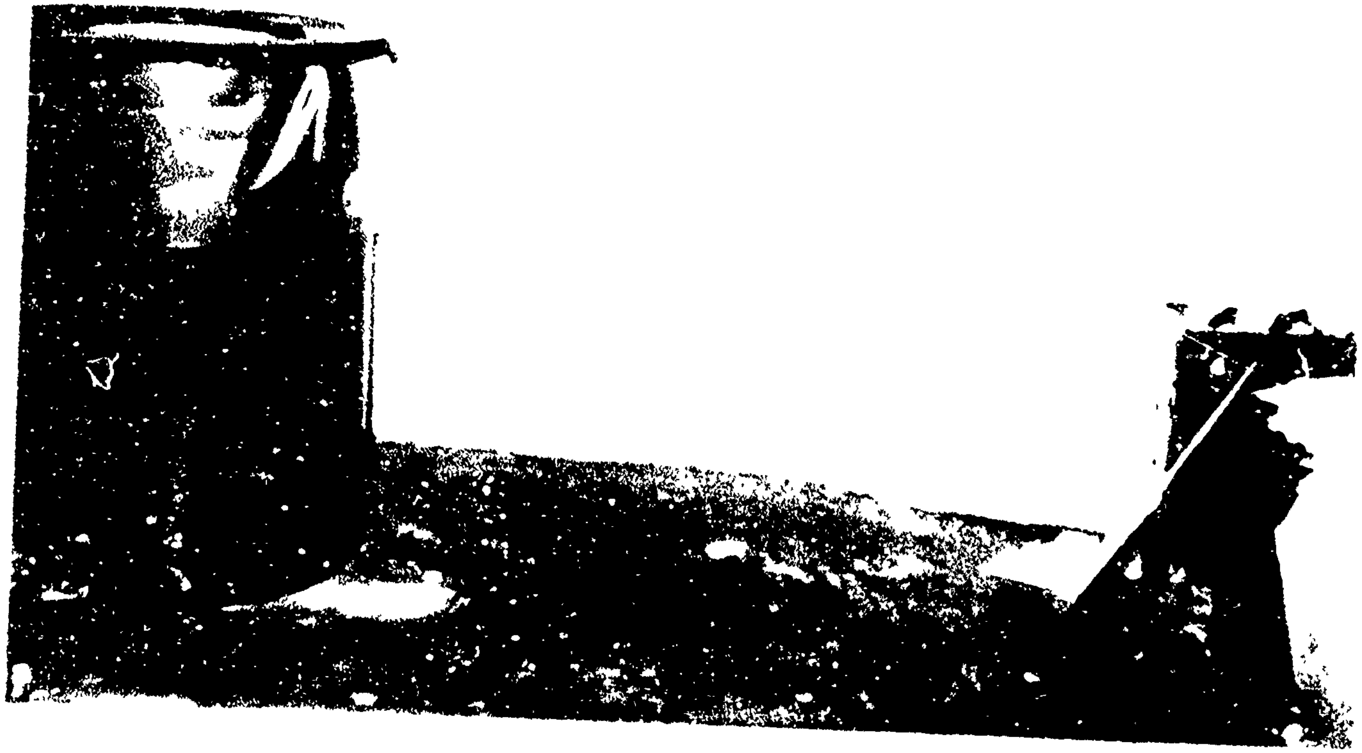

Figure 19. Post-Test View of Male Area A.

Figure 20. Post-Test: Toilet Tissue Shown Piled High in Female Vault B.

Figure 21. Post-Test: Unsanitary Condition of Male Vault C, Showing Urine and Wet Tissue on Top.

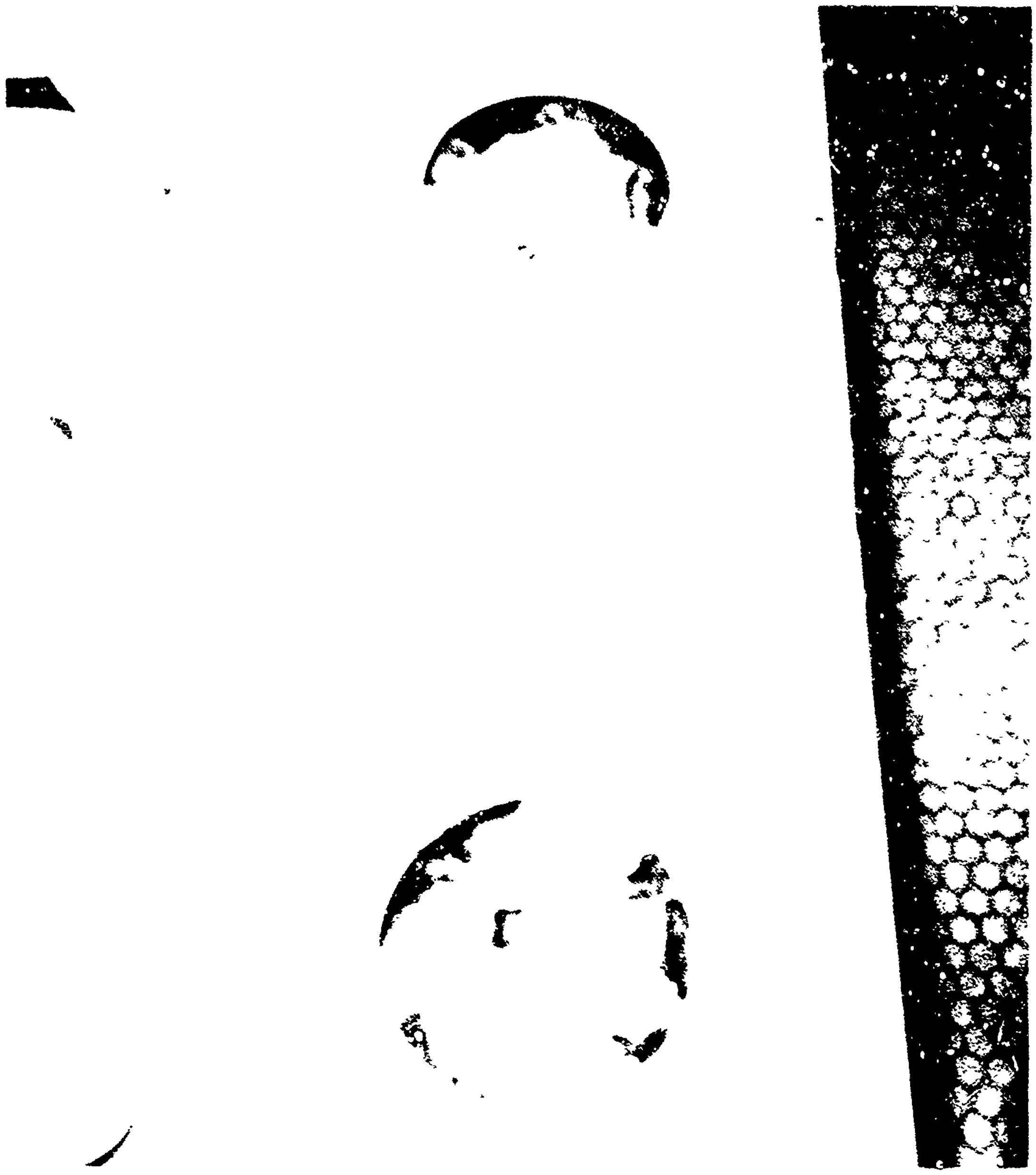

Figure 22. Post-Test: Toilet Tissue, etc., Above Splash Plates Causing Odors, Female Vault D.

Figure 23. Waste Remaining after Diaphragm Pump Blockage.

Figure 24. Physical Removal of Waste from Sanitary Vault.

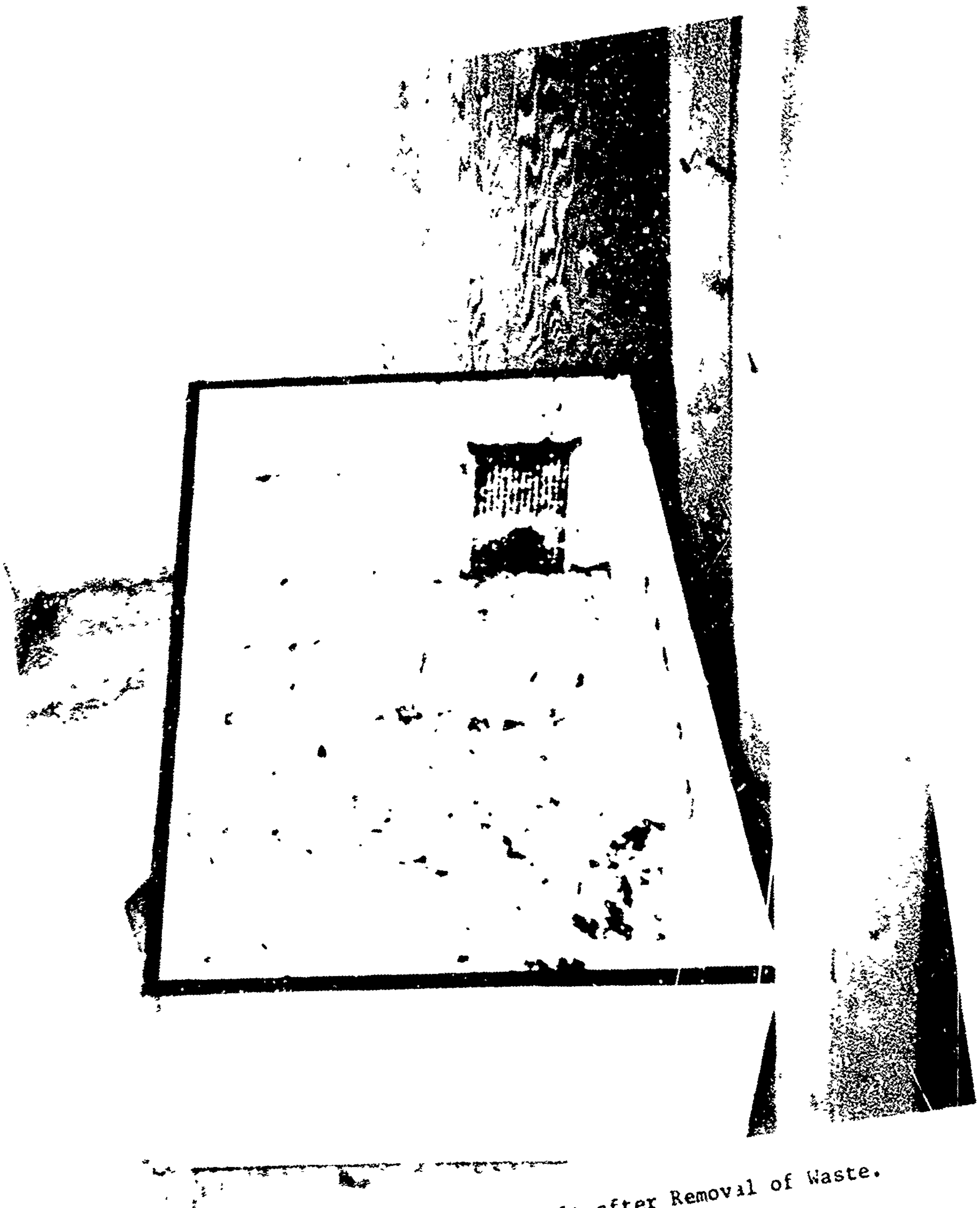

Figure 25. Sanitary Vault after Removal of Waste.

Table X

Human Waste Deposition in Male Dual-Purpose Containers, A

DATE	TIME	TOTAL HOURS	WATER ADDED (gal)	TOTAL NET VOLUME (gal)
20 Jun	0800	18.5	0.5	5.3
"	2205	32.6	-	8.3
21 Jun	1010	44.7	-	9.0
22 Jun	0815	66.8	0.5	12.8
"	1210	70.7	-	13.3
23 Jun	0940	92.2	-	17.9
"	1200	94.5	-	18.2
24 Jun	0935	116.1	0.5	21.3
"	1625	122.9	-	22.6
"	2145	128.2	-	23.8
25 Jun	1015	140.7	1.0	25.7
"	2020	150.8	-	28.1
26 Jun	0900	163.5	-	29.7

Table XI

Human Waste Deposition in Female Sanitary Vault, B

DATE	TIME	TOTAL HOURS	WATER ADDED (gal)	TOTAL NET VOLUME (gal)
20 Jun	0800	18.5	10.5	9.5
"	2210	32.7	0.5	16.7
21 Jun	2030	55.0	-	21.2
22 Jun	1200	70.5	-	21.9
23 Jun	0945	92.3	-	28.3
24 Jun	0940	116.2	-	34.7
"	1625	123.0	-	37.6
"	2200	128.6	-	38.3
25 Jun	1010	140.8	2.0	41.0
"	2025	151.0	-	45.4
26 Jun	0900	163.6	-	48.1

Table XII

Human Waste Deposition in Male Sanitary Vault, C

DATE	TIME	TOTAL HOURS	WATER ADDED (gal)	TOTAL NET VOLUME (gal)
20 Jun	0820	18.8	10.5	12.4
"	2215	32.7	0.5	23.3
21 Jun	1020	44.8	-	27.6
"	2030	55.0	-	30.4
22 Jun	0825	66.9	-	34.0
23 Jun	1045	93.2	-	43.3
24 Jun	0930	116.0	1.0 oleic acid	50.2
"	1630	123.0	-	53.7
25 Jun	1000	140.5	-	59.4
"	2015	150.7	-	64.5
26 Jun	0900	163.5	-	68.8

Table XIII

Human Waste Deposition in Female Sanitary Vault, D

DATE	TIME	TOTAL HOURS	WATER ADDED (gal)	TOTAL NET VOLUME (gal)
20 Jun	0835	19.1	10.5	16.6
"	2220	32.9	0.5	28.3
21 Jun	1415	48.8	-	34.0
"	1945	54.3	-	38.3
22 Jun	1100	69.6	-	44.0
23 Jun	0930	92.1	1.5 H_2O + oleic acid	53.2
24 Jun	0930	116.1	-	62.5
"	1630	123.1	-	66.1
"	2200	128.6	-	70.4
25 Jun	1005	140.7	1.0	74.3
"	1950	150.5	-	81.8
26 Jun	0900	163.6	1.0	88.2

of human waste accumulated in the respective commodes during the study.

These data are plotted in Figure 26, titled Deposition of Human Waste Under Fallout Shelter Conditions. It is evident that the total female waste deposited was greater than that of the male waste (See also Table XIV). The total waste collected in the study, based upon a weighted average of 263 shelterees, was 2128 lbs or 235 gallons. Water and oleic acid accounted for an additional 356 lbs or 41.5 gallons.

Table XV shows the human waste deposition rate in lbs/hr and gal/hr. The weights of chemical agent used to treat the human waste is shown in Table XVI. A total of 42 lbs of agent were expended for 229 gallons of waste. An additional 5.9 gallons of waste were disinfected with 1 quart Ozene solution (undiluted).

The individual waste deposition rates are shown in Table XVII. These figures are now documented for the first time. The average per capita waste deposition rate was 1.2 lbs/person/day or 0.13 gal/person/day.

III. DISCUSSION

6. Examination of Test Results. Because the purpose of this study was twofold, namely, the evaluation under fallout shelter conditions of: (1) the sanitary vault/diaphragm pump waste collection system and (2) the effectiveness of a preferred chemical sanitizing agent, $CuSO_4.5H_2O/NaHSO_4$ for treatment of human wastes, certain

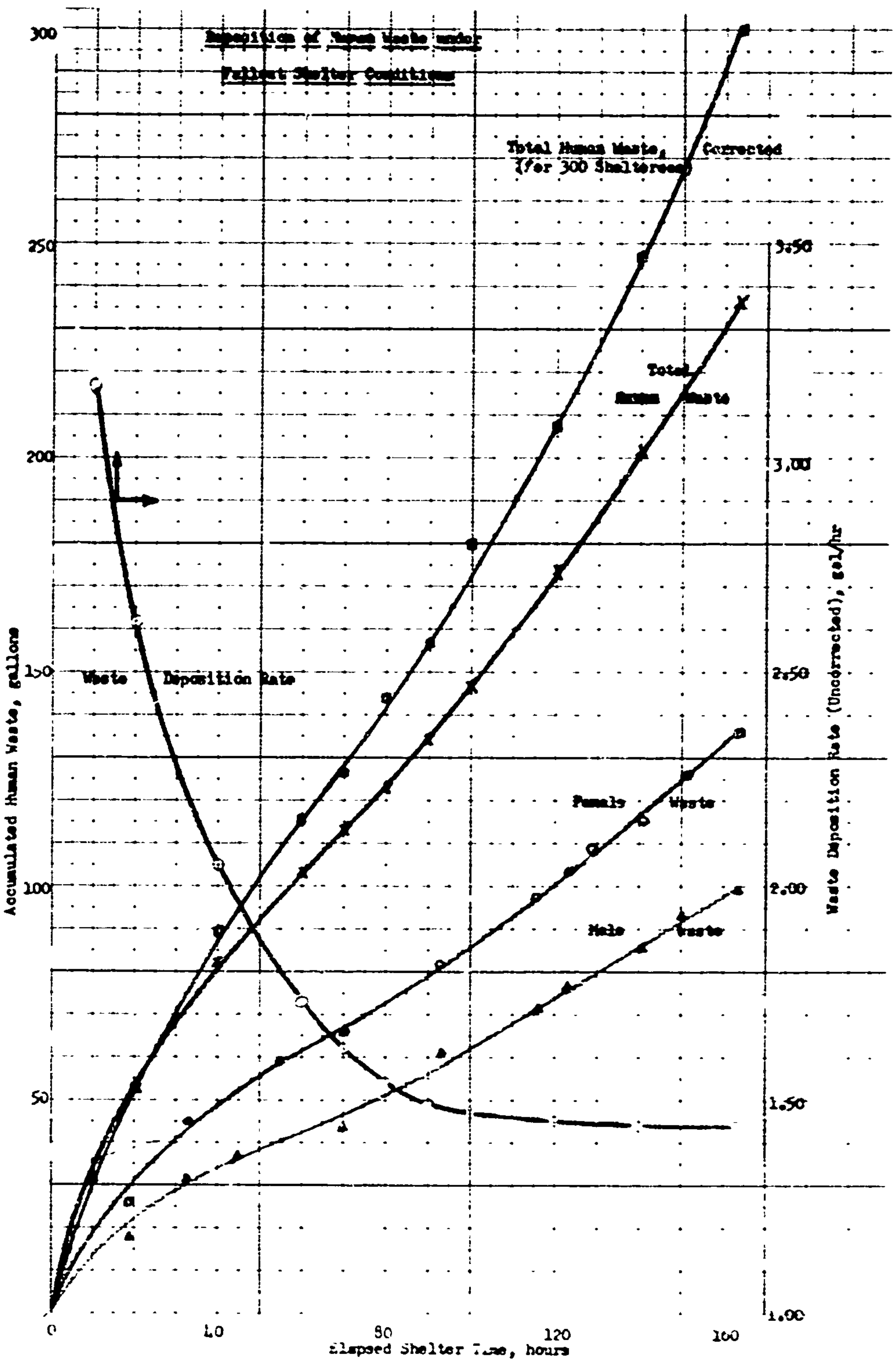

Figure 26. Deposition of Human Waste under Fallout Shelter Conditions.

Table XIV

Human Waste Deposition

COMMODE	WASTE WEIGHT, lbs (Measured)	WASTE VOLUME, gal (Calculated)
A	250	29.7
B	427	48.1
C	660	68.8
D	791	88.2
Male	910	98.5
Female	1218	136.3
Water + Oleic Acid	356	41.5

Table XV

Human Waste Deposition Rate

TIME	TOTAL NET WASTE Gal	Lbs	HUMAN WASTE RATE Gal/hr	Lbs/hr
10	31.7	287	3.17	28.7
20	52.5	476	2.62	23.8
40	82.2	745	2.05	18.6
60	103.5	937	1.73	15.6
70	113.3	1028	1.62	14.7
80	123.1	1116	1.54	14.0
90	134.2	1217	1.49	13.5
100	146.9	1331	1.47	13.3
120	173.6	1573	1.45	13.1
140	201.5	1836	1.44	13.1
163.5	236.2	2140	1.44	13.1

Table XVI

Chemical Agent Consumption

COMMODE	TOTAL AGENT USED (lbs)	NET WASTE TREATED (gal)	TOTAL WASTE TREATED** (gal)	CONCENTRATION (ppm)
A	5*	23.8*	25.5	23,500
B	13	48.1	61.1	25,500
C	9	68.8	80.8	13,300
D	15	88.2	102.7	17,500

* Additional 5.9 gal waste treated with 1 qt Ozene solution.

** Includes water used for make-up of chemical solutions.

Table XVII

Per Capita Waste Deposition Rate

UNIT	BY WEIGHT (lbs/person/day)	BY VOLUME (gal/person/day)
Male	1.11	0.12
Female	1.25	0.14
Average	1.2	0.13

observations should be referred to before definite conclusions are arrived at.

Commode sanitation, during this investigation, was practically non-existant. Various methods were devised in an endeavor to resolve this inadequacy. On the fourth day of the study, written instructions were given to the Shelter Manager to be used at his discretion (See Page 28). It took less than one day for the sanitary conditions to deteriorate to the previous status quo. A section on Sanitation must be made a physical part of the Civil Defense Shelter Instruction Manual. A sanitation lecture should be given to the shelterees by the S. M. as soon as they have settled. Each day, the respective section leaders should instruct their subordinates on good sanitation practices.

From the experience gained in this study, one can predict with reasonable sureness that male shelterees will not be seated while urinating. Despite well-placed signs and frequent oral reminders, urine spillage was observed repeatedly in both male commode areas A and C (See Figures 19 and 21). This urine spillage, upon standing, created a very unaesthetic atmosphere and constituted odor problems.

Many women were complaining constantly of the "bad odors." Since the contents of the sanitary vaults essentially were sterile, the odors evidently were caused by the reaction of the copper sulfate/sodium bisulfate agent with the feces and urine - thus producing a stale odor, not a fecal odor. The laboratory data found in Tables III and IV support this conclusion, since these odor determinations

were made by two individuals disassociated from the shelter test environment. "Apparent" fecal odors, as witnessed by women, most probably are due to inherent psychological factors resultant from visual observation of the wastes in the vaults <u>before</u> preparation for the elimination process is made by the individual. During the test, it was evident that the shelterees were not capable of differentiating between a fecal or a urinal odor or even a sweet-smelling scent such as a floral aerosol deodorant, which was used upon occasion. Upon interviewing a cross-section of women (concerning personal feelings about the commodes) from 13 to 47 years of age, the major complaint was the sight and subsequent nearness of the waste. Had most women not viewed the waste, most agreed that the odors would not have been as bad.

The results of the bacteriological examination of the waste samples were very encouraging. So long as the predetermined concentration of chemical agent was maintained, namely, 12,000 ppm (4,000 ppm copper sulfate and 8,000 ppm sodium bisulfate, respectively), and the sterilant mixture allowed to mix with the waste in a homogeneous manner, bacterial growth was minimal. No bacteria were isolated from samples with a pH of 4.0 or below. Bacteia were isolated, in some cases, from samples with a pH between 4.0 and 5.0. All samples examined with a pH of 5.0 or above exhibited bacterial activity, under the test conditions. Except in two cases, Enterococci were isolated from all samples which produced a positive, completed test for coliform bacteria, but no Clostridia were isolated. Random spot checks of the positive, completed tests for

coliform organisms revelaed _Escherichia coli_ predominating, but also _Enterococci_, _Aerobacter aerogenes_, _Pseudomonas aeruginosa_, _Bacillus subtilis_, _Diptheroids_, _Staphylococcus epidermidis_, _Proteus species_, _Aspergillus species_; and, on two occasions, _Candida species_ (in both cases, from the female vault _D_) were isolated. Smith tubes were used for gas formation determinations. In one case, a sample removed from the pumped waste from _D_ vault on 22 June, gas was formed in the Smith tube (glucose broth), but not in the presumptive test (lactose broth) (See Tables IV and V). A subculture was made and the organism responsible for the gas production was identified. The isolated organism was a Proteus, which ferments glucose with the formation of gas, but never ferments lactose.

In the future, provision should be made for the disposal of the sanitary napkins and baby diapers in containers other than the commode. Sanitary napkins have unusually high absorptive capacities and are the prime reason for the drastic reduction in the liquid level - a paramount requisite for chemical treatment of the waste. In many shelters, infants will constitute a sizable percentage of the total shelter population. Since most infants require an average of fifteen diaper changes daily, disposal of these diapers will present an insurmountable problem, if deposited in commodes.

Previous tests with oleic acid showed that the use of a vapor barrier appeared to improve the odor slightly. In this study, particularly when used in _D_ vault, the oil was absorbed by the protruding tissue and napkins and did not function properly. Odor reduction did not appear to be significant.

Throughout the test, Ozene solution was used as a disinfectant for cleansing the vault tops and floors. This chemical solution *per se*, is a powerful masking agent, which causes irritation to the eyes and upper respiratory system; prolonged inhalation of its vapors produces mild intoxication. On one occasion, Ozene was employed as a bacteriocidal agent in a dual-purpose container located in male area A. Laboratory results indicate that, at the concentration used, bacterial and odor reduction were not appreciable (See Tables III, V, and VII).

Figure 26 delineates the total human waste deposited during the shelter study (water and oleic acid not included in the results). Upon inspection of the graph, it becomes evident that the female shelterees were responsible for a larger quantity of the total waste than were the males. Under the conditions of this test, and based upon individual per capita waste outputs, female shelterees accounted for 12 percent more waste than the males did. The curve designated Total Human Waste is the summation of both the Female Waste and Male Waste plots; it represents the actual waste deposition. Since slightly more than 20 percent of the shelterees defected at different times, a more useful curve was developed which depicts what the total accumulated waste would have been if the number of shelterees remained constant at 300 (no defections). This curve may be used to predict future human waste system requirements.

A most informative plot is that of the Human Waste Deposition Rate, expressed in gal/hr, versus Elapsed Shelter Time (See also Table XV). After approximately 90 hours, this rate essentially remains

constant at 1.45 gal/hr. For shelter periods of short duration (less than 5 days), these data may be utilized for establishing sanitation requirements.

Bacteriological analyses, specific for coliform organisms, were employed on drinking water sampled from water drums located on both floors of the shelter facility. Of the seven water samples removed, two exhibited positive, completed tests for coliform bacteria and also high colony counts per 100 ml (See Table II). The organisms isolated were predominantly E. coli with some Aerobacter aerogenes. Instructions, printed on the water drums, stating how to dispense and treat the water before distribution, were not followed. Tetraglycine hydroperiodide tablets (one tablet liberates 8.0 mg I_2) as supplied, if used properly and according to the instructions, should prove a satisfactory bacterial preventive agent in the water drums. The omission of the disinfectant, as shown in the 25 June sample where contaminated residual water was added to a freshly-opened water drum, clearly demonstrates the serious health hazard which was created.

7. Evaluation of the Sanitary Vault and Chemical Agent. The sanitary vault presented a myriad of problems during the course of the waste study. Due to the presence of toilet tissue, sanitary napkins (both internal and external types), and other debris in the female vault, it became increasingly difficult to pump the waste contents, utilizing a manually-operated diaphragm pump. Each time manual pumping was attempted, clogging of the vault screen and pump suction hose resulted, with subsequent jamming of the pump inlet check valve. Upon standing,

though, the vault contents, excluding the sanitary napkins (after pushing the dry, accumulated toilet tissue downward into the liquid waste mixture with a ladle), appeared to disintegrate. Without submersion of the tissue, disintegration would have been minimal. The present vault system, lacking a macerator or comminutor device, does not allow for complete mixing of the waste with the chemical agent. Consequently, bacterial sterilization and odor control are hampered. Assuming that the pumping operation was not impaired and proceeded smoothly, when the depth of the waste was equal to or slightly less than the height of the vault discharge hole, pumping ceased. Approximately 15 gallons of thick human waste, containing a high percentage of tissue, napkins, etc., remained in the vault proper (see Figure 23). In two cases, during pumping, the scraper failed due to the shearing of the shaft at the point where it was attached to the handle. The scraper was ineffective per se and did not keep tissue from accumulating on the screen. Because Tampax unraveled into a lengthy, sash-like cord and wormed its way through the screen and into the suction hose, the diaphragm pump was rendered practically useless. Also, it was impossible to seat properly the plastic gate valve and leakage resulted. Another difficulty after pumping, particularly with the vault which did not have a valve, was the fact that the discharge hose contained waste which had to be removed. The removal of this entrapped waste presented a most unaesthetic problem. The splash plates retained waste and tissue and had to be cleaned periodically to provide a somewhat sanitary environment in the commode area. The original vault concept

envisioned pumping of the waste into an existing sewerage line or out-of-doors. Since the waste was thick and not too fluid, pumping into an existing sewerage line would not be practicable without additonal liquid to allow downstream flow of the waste. The vaults required two persons to install, since each weighed (empty, with no diaphragm pump) 120 lbs. The unit cost of the sanitary vault is detrimental: large-scale production results in a unit cost of $150 - $300. To this cost must be added the price of the diaphragm pump assembly, approximately $50. Therefore, the total unit cost, less adapters and hose, is $200 - $350. Such a high cost, together with the other disadvantages, does not merit further investigation of the present sanitary vault design. Further modifications are indicated.

It is necessary to discuss the advantages of the dual-purpose container method for human waste collection. Economically speaking, the dual-container is inexpensive. The method is simple in that it provides storage of waste in containers from which drinking water previously has been removed.

In previous reporting, much has been said about the disadvantages of this system, for example:

a. The principle of the dual-container demands that the rate of the use of the water be greater than the rate of deposition of human waste.

b. Handling of drums is required with each drum weighing approximately 155 lbs when filled with waste.

c. The height of the drum renders it difficult for use by children, elderly people, and the handicapped.

In this test, 32-1/2 drums or 4550 lbs of water were dispensed for shelter usage. This amount of water is equivalent to a rate of 2.53 lbs/person/day. This figure represents the actual water dispensed, not that physically consumed by the shelterees. This value may be on the high side, since there was spillage during distribution, and water remaining in the drums, after siphoning was discarded. Therefore, based upon the results of this study, there appears to be no apparent difficulty in providing a sufficient number of empty water drums as waste containers.

Although the original waste fill-line in the dual-container was estimated to be 19 inches or 14 gallons, the actual height of the deposited waste was 12 inches. Assuming a maximum usable waste height of 15 inches or 12 gallons, and a waste density equal to 9 lbs/gal (as determined in this study), the resultant maximum weight of such a drum would then be 117 lbs (9 lb tare for metal drum and polyethylene lining). Multiple stacking of waste-filled drums would be more practicable.

The present height of the metal drum with plastic seat is 24 inches. Utilization of an empty Civil Defense biscuit can as a foot rest reduces the inconvenience considerably.

One improvement which can be made is the fabrication of a more sturdy commode seat. The present configuration is too flexible and causes concern among the shelterees. Many shelterees preferred the dual-drum over the sanitary vault because of the knowledge that the drum eventually would be removed and replaced by a new one.

Other advantages of this system include such features as no moving parts, no chance for waste leakage, and no pumping requirement.

In larger shelters, the dual-drums may be used because, proportionally, the waste deposition will be the same. If these shelteres are stocked with metal drums filled with water, the floor space required for the waste containers will be the same and multiple stacking will present no additional problems since each waste-filled drum will weigh 117 lbs compared to 150 lbs for the water-filled drum.

All matters considered, the Civil Defense dual-purpose continaer, as employed in commode area A in this study, provides both a simple and economical method for storage of human waste.

According to Bidzinski, in 1926 (Bacterial Chemistry and Physiology, Porter, 1947), 0.3500 grams per liter (3500 ppm) $CuSO_4$ are a lethal concentration for *Pseudomonas aeruginosa* and 0.2862 grams per liter for *Staphylococcus aureas*. Sprowls and Poe, in 1943 (ibid.), found that copper salts were more toxic to *Salmonella typhosa* than to *Staphylococcus aureas*. Results from past laboratory investigations indicated an effective concentration at a dosage of 4,000 ppm cupric sulfate petahydrate. This value compares favorably with the Bidzindki determination. Throughout this shelter study, the minimum average concentration of chemical agent maintained was 13,300 ppm or 4,400 ppm $CuSO_4.5H_2O$ (see Table XVI). Lack of proper mixing prevented complete sterilization of the waste, in isolated instances. The laboratory results affirm that the chemical agent used in this study proved to be an effective bactericidal agent.

IV. CONCLUSIONS

8. Conclusions. Based upon the results of this study and under the test conditions, it is concluded that:

a. It is practically impossible to prevent the male shelterees from standing while urinating.

b. The use of a vapor barrier chemical, oleic acid, does not appear to reduce emanation of waste gases appreciably.

c. "Apparent" fecal odors are a result of inherent psychological factors, propagated by both the sight and subsequent nearness of the human waste before the elimination process begins.

d. Odors of the type experienced in this test - chemically stale urine - can be reduced substantially by closure of the commode seat after each usage.

e. So long as the predetermined concentration of chemical agent, namely, 12,000 ppm $CuSO_4 \cdot 5H_2O/NaHSO_4$, is maintained and the sterilant mixture allowed to mix with the waste in a homogeneous manner, bacterial growth is minimal.

f. The per capita human waste deposition rate is 1.2 lbs/person/day or 0.13 gal/person/day.

g. The present design of the sanitary vaults used in this study does not lend itself to shelter usage and further modifications are indicated.

h. The Civil Defense dual-purpose container is the more practicable and economical method for storage of human waste in the confined environment of a fallout shelter.

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APPENDIX

DAILY LOG OF HUMAN WASTE STUDY

Date	Time	Remarks
19 June	1155	Start of test, first person in front door.
	1330	Due to lack of effective control SK4's closed off, removed, and sanitary vaults (3) and H_2O drum activated using $CuSO_4/NaHSO_4$ as a disinfectant. Initial one pound chemical agent dissolved first in 2 qts H_2O, then added to 10 gal H_2O in vaults B, C, and D; 1/2 lb agent in 2 qts H_2O added to drum A.
	1500	Disposed of a wet, cloth diaper, just before girl was to deposit same in D vault.
	1530	All sanitary vaults functioning well; no odors as yet. A drum has urine in it, no feces; smells uriny. Boys wetting seat (also C vault). Need commode monitors badly. Told Director of Operations to appoint C.M. (male and female) immediately. Temperature (second floor) -80°F, THI -75.
	1615	A area smells stale; no feces yet; very few male adults on second floor. Seat wet from standing urinations; little boys cannot read signs.
	1625	Fans turned on - second floor.
	1630	Second floor count: 18 boys (16 years old and under), 1 old man, 3 male adults; 45 females (all ages). D, toilet tissue piling up under seats; must move around with ladle.
20 June	0800	1/2 lb agent, dry, added to A. Seat wet with urine. Stale odor. 2 lbs agent in 2 qts H_2O added to B. Moved heaped toilet tissue around.
	0820	C. Urine all over seats; not much tissue in vault. Odor stale. Added 2 lbs agent in 2 qts H_2O.

Date	Time	Remarks
20 June	0835	D. Odor, not so stale. Added 2 lbs agent in 2 qts H_2O to vault. Odor (staleness) reduced greatly after addition of chemical agents and cleaning of splash plates and underside of seats with a HTH solution.
	0845	Odor much improved - no staleness. Commode monitors finally placed on duty by Dir of Operations. A C.M. was on duty at all times in area D.
	1030	Checked SK4 commode chemical and found that 2 of the 24 - 10 gm packages had been used in B and 1 used in D in error.
		C. Urine all over top of vault; odor becoming stale again.
	1155	A. Sample taken. Odor fair. One sheet of typed instructions (?) in drum.
	1200	B. Sample taken. Seat covers closed. Odor good. Much toilet tissue.
	1205	C. Sample taken. Seat covers open. Odor fair (stale).
	1210	D. Sample taken. Seat covers closed. Odor good. Much toilet tissue. Difficult to take sample.
	2205	A. 1/2 lb agent, dry, added. Open drum top. Odor fair.
	2210	B. 2 lbs agent, dry, added. Seat covers closed. Odor good. Much toilet tissue below vault seats.
	2215	C. 2 lbs agent, dry, added. Seat covers open. Odor extremely stale. Urine all over splash plates and vault top.
	2220	D. 2 lbs agent, dry, added. Seat covers open. Odor very stale. Much toilet tissue below vault seats.
		Urine all over splash plates and around seats. (Females possibly squatting?)

Date	Time	Remarks
21 June	0840	A. Odor fair (stale). Sealed off drum and installed a new one with 1/2 lb agent dissolved in 2 qts H_2O.
	0900	B. Odor good. Second floor now has: 32 males and 52 females.
	0905	C. Odor stale.
		D. Odor good (urine). Some women complaining (B & D areas) about odors; some outright refuse to use commodes.
	1010	A. Sample taken of closed-off drum (0845 hrs.).
	1015	B. Sample taken.
	1020	C. Sample taken.
	1025	D. Sample taken. Sprayed area with floral room deodorizer after cleaning area with HTH solution.
	1325	Some women still complaining about commode odor; floral spray of no consequence in masking odors. Comment: D area smelled of stale urine at 1025 hrs. Area sprayed with floral deodorizer until experimentor could hardly stand smell (smelled like roses). Two women entered area D a few moments after area was sprayed. Their comments upon exit were that it still smelled bad. Therefore, there appears to be a psychological "conditioning" of these women in that they must feel that, since a commode (outhouse or privy) usually is odoriferous, it must also smell bad now. (Will discuss this point later).
	1415	D. Tissue piling high. Odor somewhat fecal.
	1445	Second floor. Water sample taken from a drum 2/3-full (4th water drum in use on second floor).
	1500	First floor (left room facing entrance). Water sample taken from drum 1/3-full.

Date	Time	Remarks
21 June	1515	Added 1 - 10 gm package of SK4 phenolic agent to trash can (top of SK4) in area B (appears that some used sanitary napkins have been deposited there.)
	1530	Added 2 - 10 gm packages of phenolic agent to trash can (SK4) in area D. Used sanitary napkins in can; must close off; odor bad.
	1600	Shelter Manager informed me that females have been informed to dispose of used sanitary napkins in commodes.
	1915	Second floor. 84° ambient. R.H.-35%. THI-75. Empty metal cracker cans being thrown in trash instead of utilizing them as trash (small) cans.
	1920	A. Odor good. Cover over drum. Trash and garbage in empty cracker cans (3).
	1925	B. Odor fair.
	1945	D. Odor semi-bad. Much tissue. Added 2 lbs agent, dry; pushed tissue down and aside. Will pump tomorrow (a.m.).
	2000	C. Two men shaving in commode area. Water cups strewn about (along edges of shelter walls); very dirty. Suggest a very sticky tape be supplied to attach water cups (empty) to wall, up high, out of way. Water distribution point (first floor, left) sloppy - drippage on floor.
	2030	C. Odor very stale. Added spice deodorant spray.
		B. Odor fair to good.
	2035	A. Odor good.
	2045	A. Added 1/2 lb agent, dry.
22 June	0815	A. Odor stale. Sprayed area with spice deodorant.
	0820	B. Odor bad. Sprayed area with spice deodorant.

Date	Time	Remarks
22 June	0825	C. Odor fair. Urine all over vault top; floor dirty.
	0830	D. Odor bad (fecal). Too much toilet tissue used. Height of waste - 9-3/8 in.; must pump.
	0930	Solution of emulsifiable o-dichlorobenzene made up: 1 pint Ozene/1-1/2 gal total solution.
	1000	Discussed movement of medical area (located to right of men's commode area, first floor) with Shelter Manager so D vault could be pumped out. Also, new rules for commode usage were discussed with S.M.
	1030	D. Sample taken. Odor bad. Prepared chemical agent for D vault: 2 lbs agent plus 2 qts H_2O plus 1 gal oleic acid.
	1035	C. Sample taken.
	1100-1130	D. Sanitary vault pumped out using manually-operated diaphragm pump. Scraper broke where shaft is threaded into handle. Had to scrape waste from screen manually. UGH! Pumping terminated because of blockage by tissue and unraveled Tampax. (Tampax, it appears, is notorious for unraveling and looked like a long sash when pulled from suction side of pump.) Total waste pumped from D vault - 5-1/4 in. Area washed down with Ozene solution. Could not seat plastic gate valve (on vault) because of blockage (unraveled Tampax). Could only pump 2-1/2 water drums-full out because of blockage.
	1200	B. Sample taken.
	1210	A. Sample taken. 1/2 lb agent added, dry.
	1230	D. Sample taken of pumped waste.
	1300	D. Area reactivated for use as per Shelter Manager's instructions to Commode Monitor. S.M. was given written instructions.

Date	Time	Remarks
22 June	1315	C. Cleaned area out with Ozene solution. S.M. will activate vault as per new instructions.
	1845	D. Too much tissue in vault; area clean; Ozene odor persisting.
		C. Urine on top of vault; need stricter supervision.
	2100	Emergency call from George Anderson (Jim Watson); D vault leaking on floor. (Probably because valve not seated properly.)
	2130	Checked leak in D vault. Leakage wet shelteree's (female) quilt and pillowcase. Appeared to be leaking around bolts holding valve assembly to vault housing. Tightened hex bolts with 7/16" wrench. Placed sealing compound around "O" ring and valve assembly, but believed that it only temporarily will relieve problem. Placed paper towels saturated with Ozene solution around valve assembly after thoroughly washing floor inside D commode area and outside (wet area) with Ozene solution. Will have to clean periodically and replace towels. Cannot do anything else until termination of test on Saturday. When D vault is filled, will not pump; will utilize metal dual-drums until end of test. Must live with this problem - this must be rectified mechanically. Also, the buildup of toilet tissue is almost unbelievable: even though instructions were given by S.M. to C.M., females still using an extreme amount of tissue. Must make some adjustments in disposal of (a) diapers, (b) sanitary napkins, e.g., Modess, Kotex, and Tampax (the latter is the real problem as it unravels in the commode into a sash-like string blocking the pump operation completely).
23 June	0925	C. Odor stale. Urine all over vault.
	0930	D. Odor good. Loaded with tissue (waste contains almost all tissue, not much liquid). Leak around valve stopped.

Date	Time	Remarks
23 June	0940	A. Odor fair. Height of waste - 11-3/8 in. Should have added chemical agent at 6 in. level. Toilet tissue present; cover off.
	0945	B. Odor good. Much tissue present; semi-clean area; trash about; seats closed.
	1015	D. Sample taken. So much tissue present that it made sampling with plastic baster almost impossible.
	1025	C. Sample taken. Will pump shortly.
	1030	B. Sample taken.
		A. Sample taken. Odor good, with cover on; bad, without.
	1045-1110	C. Vault pumped out manually until diaphragm would not function due to jamming of check valve by tissue, etc., on suction side of pump. Discharge hose had to be drained by gravity so as not to present any problem after the hose was hung up and tied to wall. Total waste pumped - 2-7/8 in.; not much tissue present as compared to B and D vaults. Area cleaned with Ozene solution.
	1130	C. Sample taken of pumped waste.
	1200	A. Added 1/2 lb agent, dry, and sealed off drum; added 1/2 lb agent plus 2 qts H_2O to new drum.
	1210	B. Added 2 lbs agent, dry, to vault.
	1610	D. Changed paper towels around valve. Some apparent leakage with Ozene solution. Noticed a blue face towel hanging to dry on side of vault.
24 June	0930	C. Odor fair. Urine all over vault and seats.
		D. Odor fair. Toilet tissue all the way up to commode seats (above splash plates).

Date	Time	Remarks
24 June	0935	A. Odor bad-fair. Top off drum. Whole roll of tissue in drum (someone was playing basketball); filthy water cups (2) on window sill.
	0940	B. Odor fecal. Tissue up to commode seats (above splash plates); bloody sanitary napkins on top of dry tissue below commode seats. B vault cannot possibly be pumped out due to the extremely high tissue/liquid ratio.
	0945	A. 1/2 lb agent, dry, added.
	1005	C. Sample taken.
	1010	D. Sample taken. Odor bad (fecal).
	1015	B. Sample taken. Odor fair (fecal).
	1030	D. Leak still prevalent around valve assembly; will change paper towels later today.
	1300	Photos taken of all commode areas: A, B, C, & D.
	1325	H_2O sample taken from second floor distribution point. Hands of distributor touched water siphon hose tip and water itself.
	1330	H_2O sample taken from first floor, center, distribution point. Sanitary dispensing.
	1430	Cleaned C and D areas with Ozene solution; possible leak in C vault; will check later. Both B and D vaults smelling fecal because of waste atop tissue which is piled high above liquid level.
	1625	A. 1/2 lb agent added, dry. Odor fair. Urine all over seat and floor.
		B. 2 lbs agent added, dry. Odor fair (ammoniacal). Loaded with tissue, sanitary napkins, etc.
	1630	D. 2 lbs agent (Truesdail) added, dry. Odor fecal. Toilet tissue piled high; feces, sanitary napkins on top.

Date	Time	Remarks
24 June	1630	C. 2 lbs agent (Truesdail) added, dry. Cdor good.
	2100	Checked women's vaults B and D; very bad fecal odor. Also tissue again piling up to an extreme level; must shut off and use water drums for duration of test. B. Added 2 - 1/2 lb packages (1 lb total) and 1 gal H_2O to a water drum; repeated same for second water drum (2 water drums used in B area).
	2145	A. Tied off P.E. bag and removed filled drum. Added new water drum containing 1 pint Ozene plus 1 gal H_2O.
	2200	Shut off B vault (taped seats closed and wrote signs instructing that metal drums be used). Activated the two metal drums. Odor ammoniacal (most likely from fermenting urine which is in napkins and tissue laying on top of the liquid level where no chemical agent is able to react properly). Tissue so high it is forcing commode seat up. Photos taken. Height of waste - 8-5/8 in. Shut off D vault and brought in one metal water drum containing 1 lb agent and 1 gal H_2O. Height of waste - 9-1/4 in.
25 June	0930	Sprayed A and B with floral deodorant. Checked commode drums in A, B, & D; all functioning well; odor fair-good; C has urine all over top and floor.
	1000	C. Odor stale.
	1005	D. Odor good. Paper towels on valve wet; need changing.
	1010	B_1 and B_2 (drums). Odor slight NH_3.
	1015	A. Odor of diarrhea.
	1030	D. 1/2 lb agent, dry, added.
	1105	A. 1/2 pint Ozene added.
	1120	D. Changed wet paper towels around valve and placed new ones and Ozene solution on them to control drippage from vault.

Date	Time	Remarks
25 June	1140	Water sample taken, second floor distribution point. Drum 1/3-full; I_2 tablets were placed in as per instructions on drum.
	1150	Water sample taken, first floor, center. Drum 1/3-full; no I_2 tablets added. (Water from previous day's contaminated drum poured into this drum). Not a sanitary dispensing.
	1205	Water sample taken, first floor, left. Drum 1/3-full; I_2 tablets added as per instructions on drum.
	1645	B_1 and B_2. 1/2 lb agent, dry, added to each drum. Odor fair.
	1650	D. 1/2 lb agent, dry, added to drum. Odor fair (fecal). Toilet tissue piled high in drum.
	2000	D. Added 1/2 lb agent to drum and tied off P.E. bag. Brought in another drum. Added 1 lb agent (Truesdail) and 1 gal H_2O to new metal drum.
	2015	C. Height of waste - 11-1/2 in. Urine all over top - a real mess (dripping on floor, too!)
	2020	A. Top cover on floor; room very hot and humid; odor good (due to masking qualities of Ozene).
	2025	B_1 and B_2. Odor fair.
	2130	A. Added 1/2 pint Ozene.
	2250	B_1 and B_2. Added 1/2 lb agent, dry, to each drum. Noticeable NH_3 odor.
	2300	D. Added 1/2 lb agent, dry.
26 June	0900	Shelterees allowed to leave.
	1010	A. Sample taken. Odor bad. Trash all over; cover off and on floor.
	1015	B. Sample taken from vault. Odor ammoniacal. (NH_3 odor from waste not submerged). This female area fairly clean.
		B_1 and B_2. Samples taken.

Date	Time	Remarks
26 June	1025	C. Sample taken from vault. Odor fair. Complete and utter chaotic mess!
	1030	D. Sample taken from vault. Area fairly clean. Samples taken from D_1 and D_2 (drums).
		D. Pumped two drums 2/3-full with diaphragm pump (wastes deposited in vault seemed to disintegrate upon standing). No trouble pumping as long as liquid is present. Pumping stopped when waste thickened and remaining waste scooped out by hand. Scraper had been sheared off at nut near top. Discharge hole in vault blocked with an unraveled Tampax. Vault D set outside and a HTH solution placed into it to sterilize any remaining bacteria.
		C. Contents mostly liquid, not much tissue. Color of liquid greenish-brown. As soon as liquid level reached depth of height of discharge hole, pumping almost ceased. Had to scoop out rest of thick waste. Need macerator or comminutor device badly; also larger diameter discharge hose. Valve on pump suction jammed by tissue during shelter test.
		B. About 1/3 of the volume is composed of sanitary napkins and toilet tissue. Color of liquid reddish-brown (blood from sanitary napkins very obvious in liquid). Never could have pumped contents with diaphragm pump - too thick a mixture. The scraper was operable, but was not used. Many, many sanitary napkins evidenced. All wastes (B, C, & D) appear to disintegrate upon standing due to action of chemical agent on waste material. All but large stools (tightly compacted, due to constipation) disintegrated. Toilet tissue also disintegrated to some extent.

Figure 27. Shelter Facility, First Floor, Pre-Test.

Figure 28. Office and Work Area Used in Human Waste Study, Second Floor Observation Area.

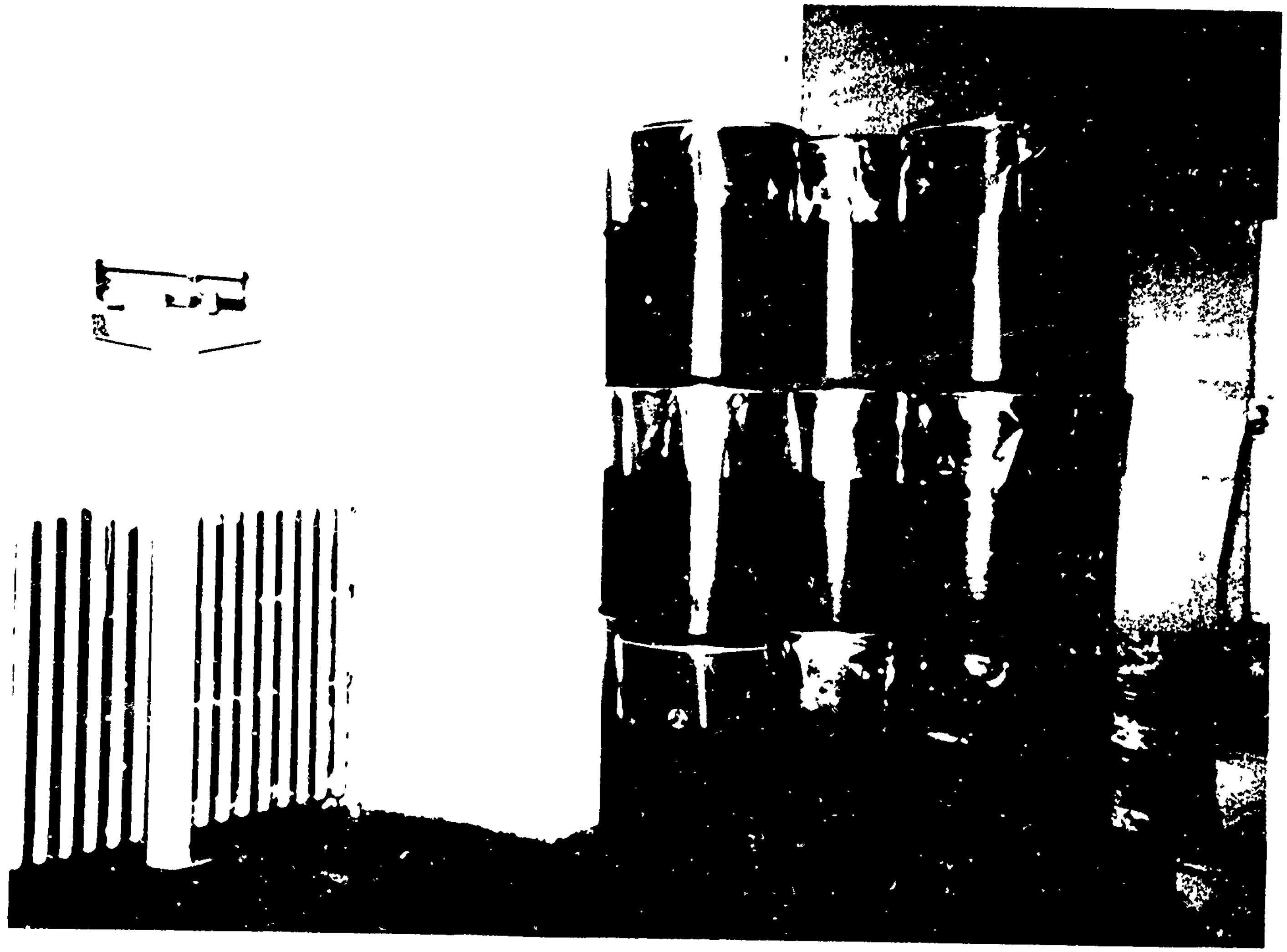

Figure 29. Waste Weighing and Storage Area, First ·loor Rear.

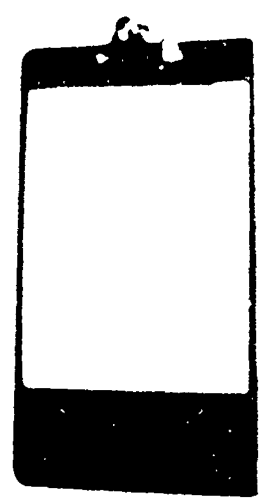

Figure 30. Clip-Board with Data Sheet Used for Collection of Subjective Observations.

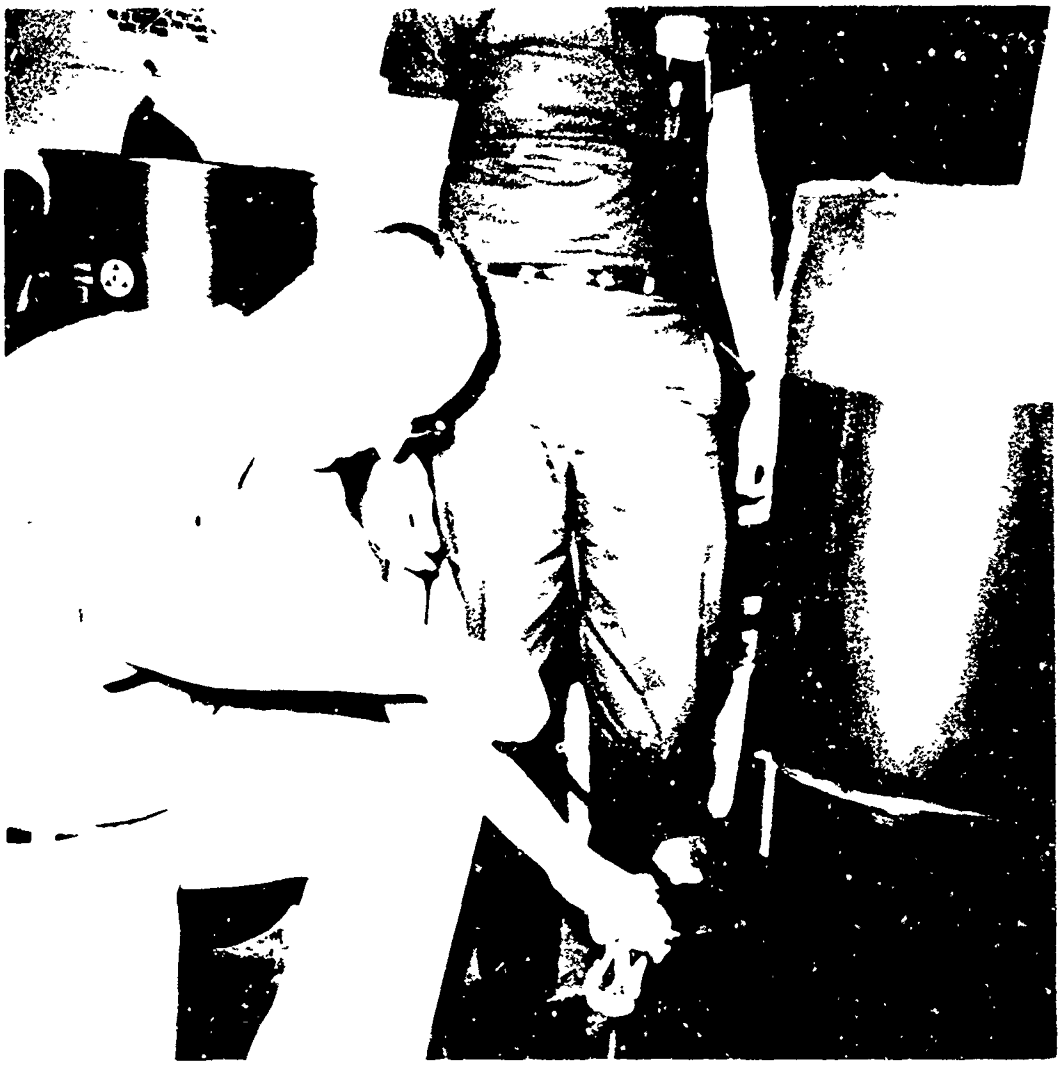

Figure 31. Collection of Water Sample, First Floor.

Figure 32. Demonstration of Drinking Cup Leakage.

Figure 33. Frontal View of Commode Area on First Floor Showing Location of Shelterees.

Figure 34. Water Distribution and Trash Disposal Points, Secr ' Floor.

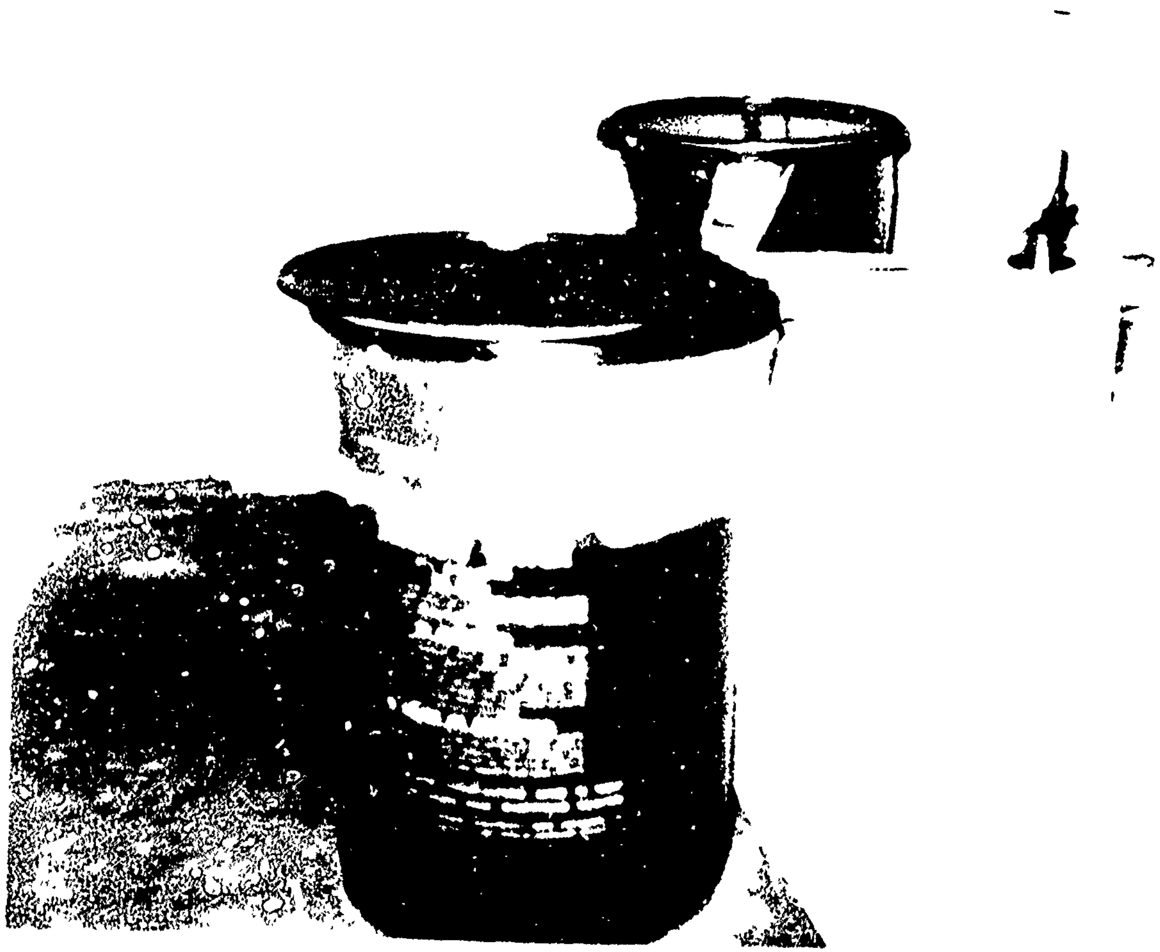

Figure 35. Dual-Purpose Drums Used in Female Area B, after Vault Use Terminated.

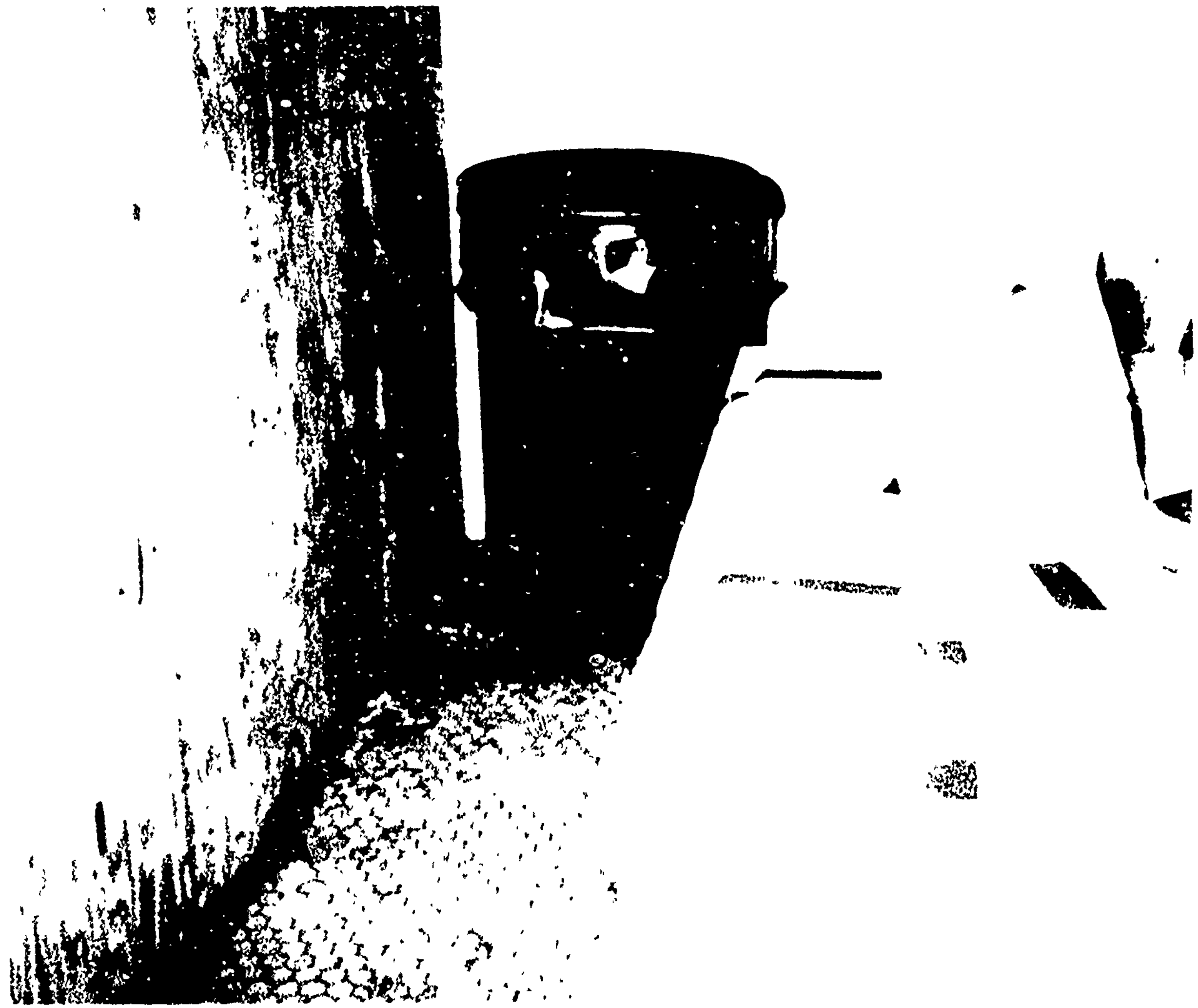

Figure 36. Female Area D after Taping Vault Shut and Installation of Dual-Drum.

Figure 37. Technician Removing Sanitary Vault Top Prior to Emptying, Post-Test.

Figure 38. Emptied Sanitary Vault Depicting Broken Scraper

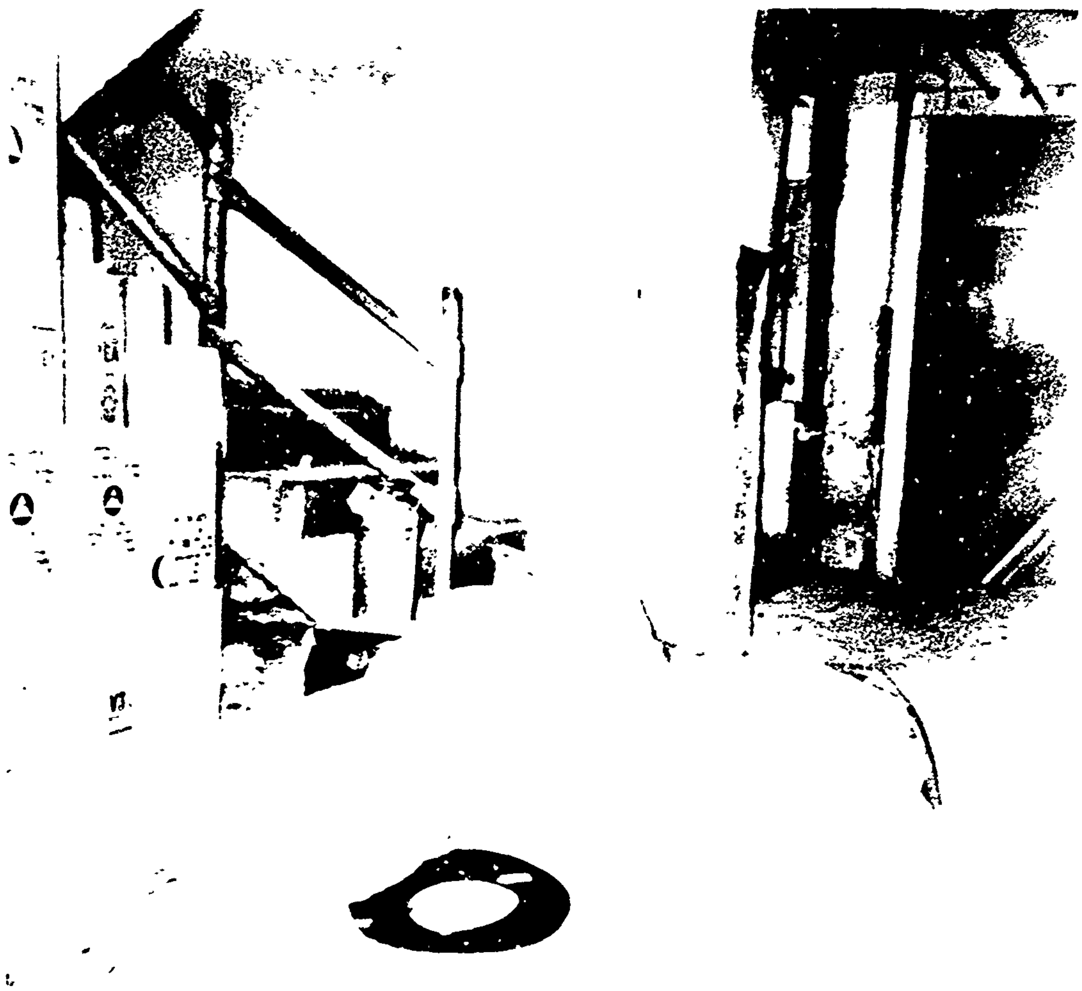

Figure 39. Collected Trash Thrown Down Stairwell During Study.

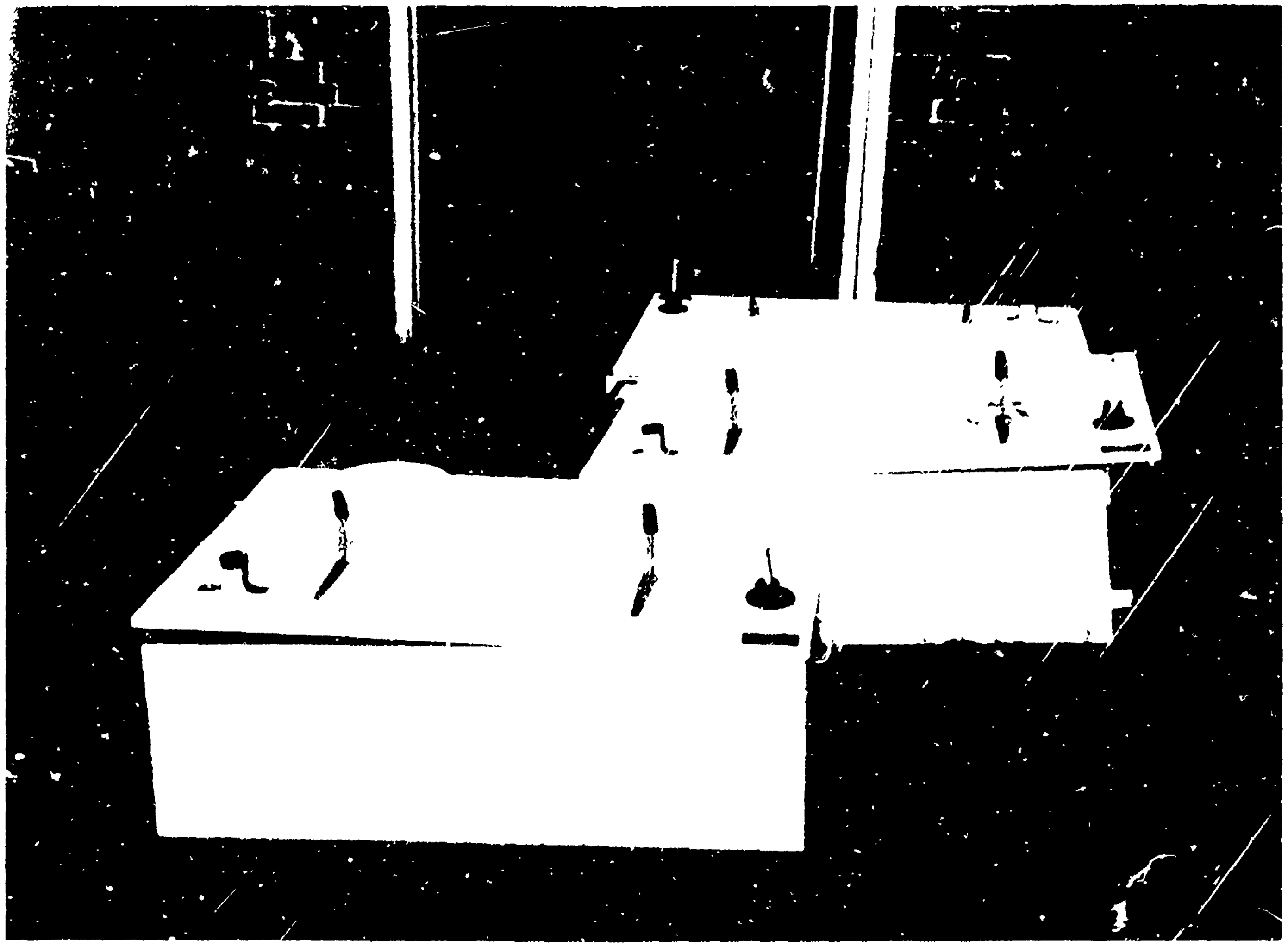

Figure 40. Emptied Sanitary Vaults Used in Study, Post-Test.

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